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TECHNICAL REPORT T-CR-77-5

LEVEL 4

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THEORETICAL ANALYSIS OF THE FLOW FIELD OVER A FAMILY OF OGIVE BODIES - VOLUME II

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20 August 1979

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U.S. ARMY MISSILE COMMAND

Redstone Arsenal, Alabama 35809

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Tangent ogive bodies	Center of pressure
Angle -of - attack	Analytical methods
Pitching moment coefficient	Spherically blunted ogives
Normal force coefficient	Pointed tangent ogive bodies

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Local normal force distributions are presented for pointed tangent ogive bodies and spherically blunted tangent ogive bodies at free stream Mach numbers of 2 to 4.5 at 2° angle-of-attack. Also, total or integrated values of normal force coefficients, pitching moment coefficients, and centers of pressure are given for all body shapes as a function of free stream Mach number for the same angle of attack. These data were obtained using the US Army Missile Command three-dimensional method of characteristics computer code. This volume is intended as a second volume to MIRADCOM technical

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ILLUSTRATIONS

ILLUSTRATIONS

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ILLUSTRATIONS (Concluded)

1. INTRODUCTION.

Reference 1 presents drag, surface pressure distribution, and surface Mach number distribution for a family of spherically blunted ogive forebodies for a range of fineness ratios and bluntnesses (including the sharp pointed bodies). Reference 1 also describes the analytical methods used to calculate the data. This report presents further data from the same analytical data base. Specifically, local normal force, total normal force coefficient, total pitching moment coefficient, and center of pressure are given for the supersonic (M_∞ = 2 to 4.5) angle of attack (α = 2°) cases.

Table 1 lists the configuration parameters for the forebodies included herein. (Reference 1 contained an additional body not included here.) Bluntness ratio is defined as the ratio of the radius of the nose sphere to the radius of the forebody base; fineness ratio as the ratio of the (truncated) length of the forebody to its diameter.

This report is limited to those supersonic cases for which the MICOM Three Dimensional Method of Characteristics Program can be applied providing accurate angle of attack data. Note that under these conditions there is no influence on the forebody flow from the afterbody.

2. DISCUSSION.

Local normal force coefficient, $dC_N/d(x/D)$, is presented in Figures 1 through 19. The hemispherical forebody (#13) is shown in Figure 19 for all free stream Mach numbers on a sliding origin graph for compactness.

Figures 20 through 34 depict integrated values of normal force, moment coefficient, and center of pressure as they vary with free stream Mach number for body shapes 1 through 13. The values of center of pressure are CM/CN. The radial displacement of the center of pressure has been calculated but is sufficiently small at two degrees angle of attack that inclusion in this report is not worthwhile. Figures 35 through 37 show similar data for the pointed forebodies. The values calculated using non-linear slender body potential theory for M_∞ = 1 also are indicated on these plots. This program is discussed in the original volume (Reference 1) and Reference 4.

TABLE I. LIST OF BODY SHAPES

BODY SHAPE	BLUNTNESS RATIO	FITNESS RATIO	R_N
1	.2	4	.1
2	.2	3	.1
3	.2	2	.1
4	.4	4	.2
5	.4	3	.2
6	.4	2	.2
7	.6	4	.3
8	.6	3	.3
9	.6	2	.3
10	.8	4	.4
11	.8	3	.4
12	.8	2	.4
13	1.0	.5	.4
14	0	4	0
15	0	3	0
16	0	2	0

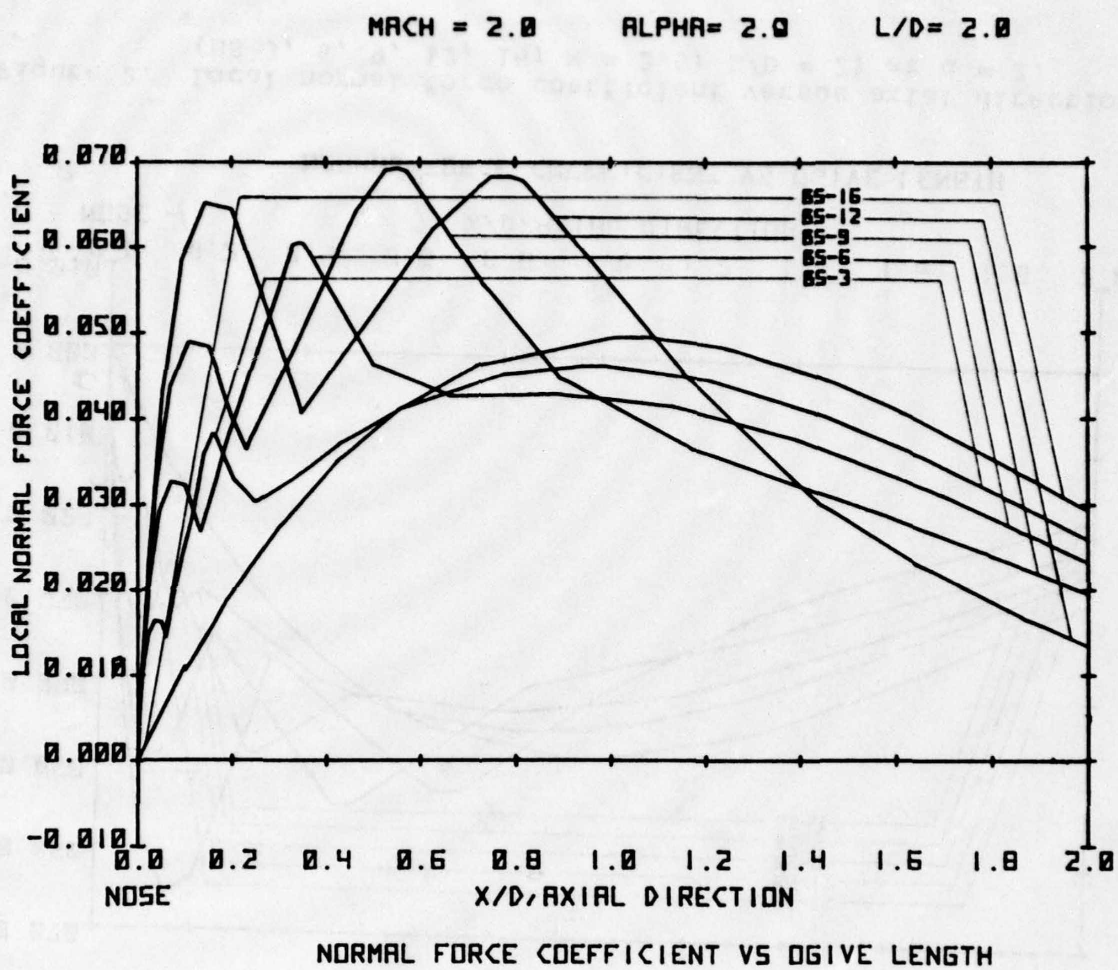


Figure 1. Local normal force coefficient versus axial direction (BS = 3, 6, 9, 12, 16; M = 2; L/D = 2) at α = 2.

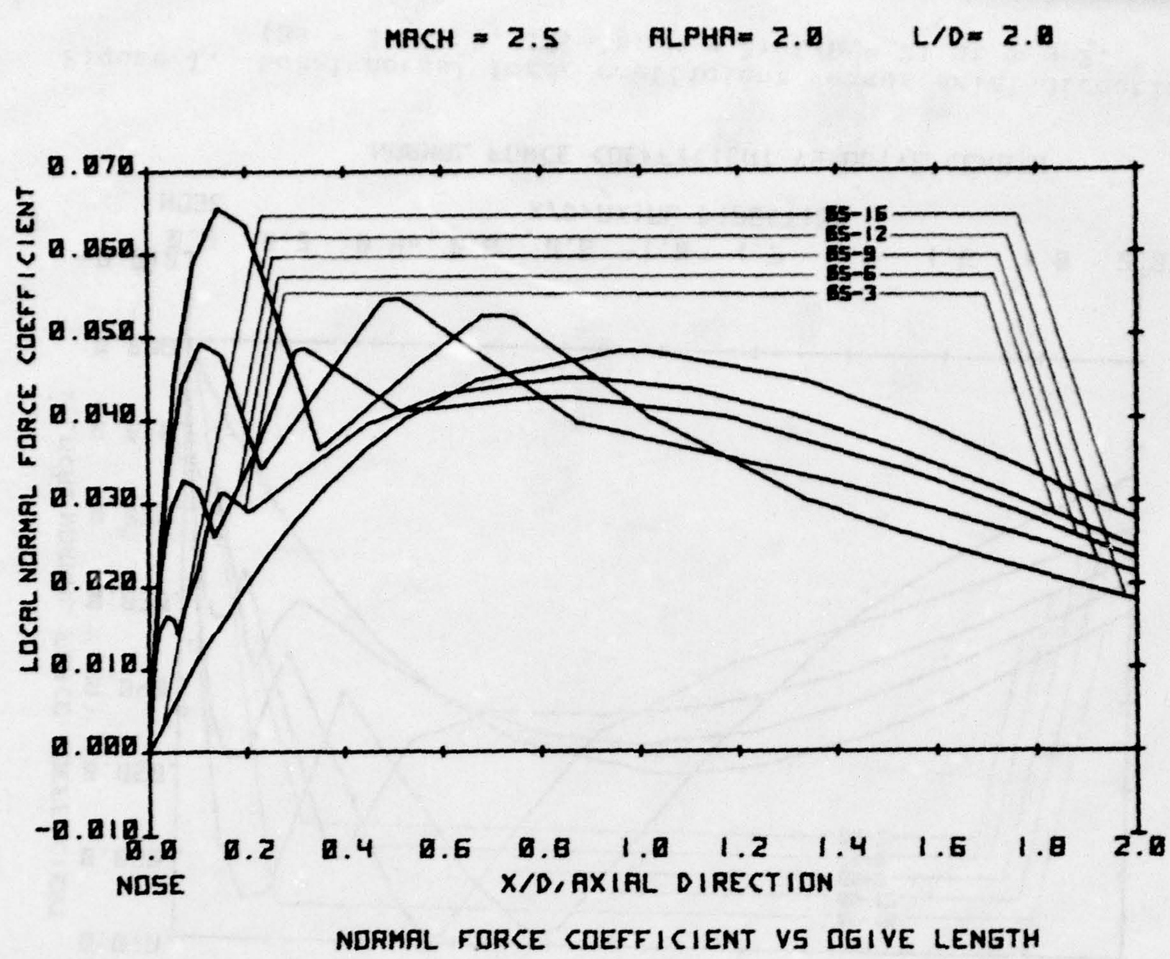


Figure 2. Local normal force coefficient versus axial direction (BS 3, 6, 9, 12, 16; M = 2.5; L/D = 2) at α = 2.

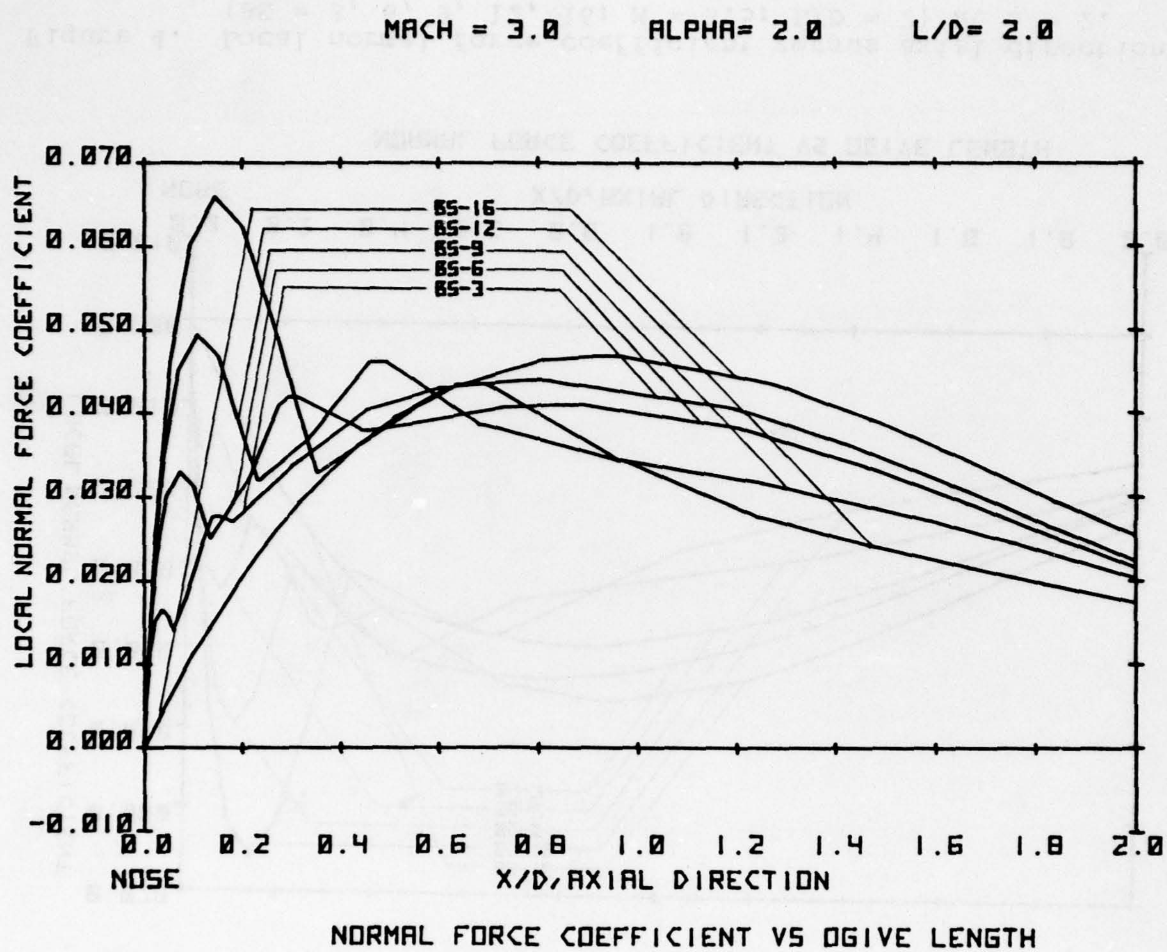
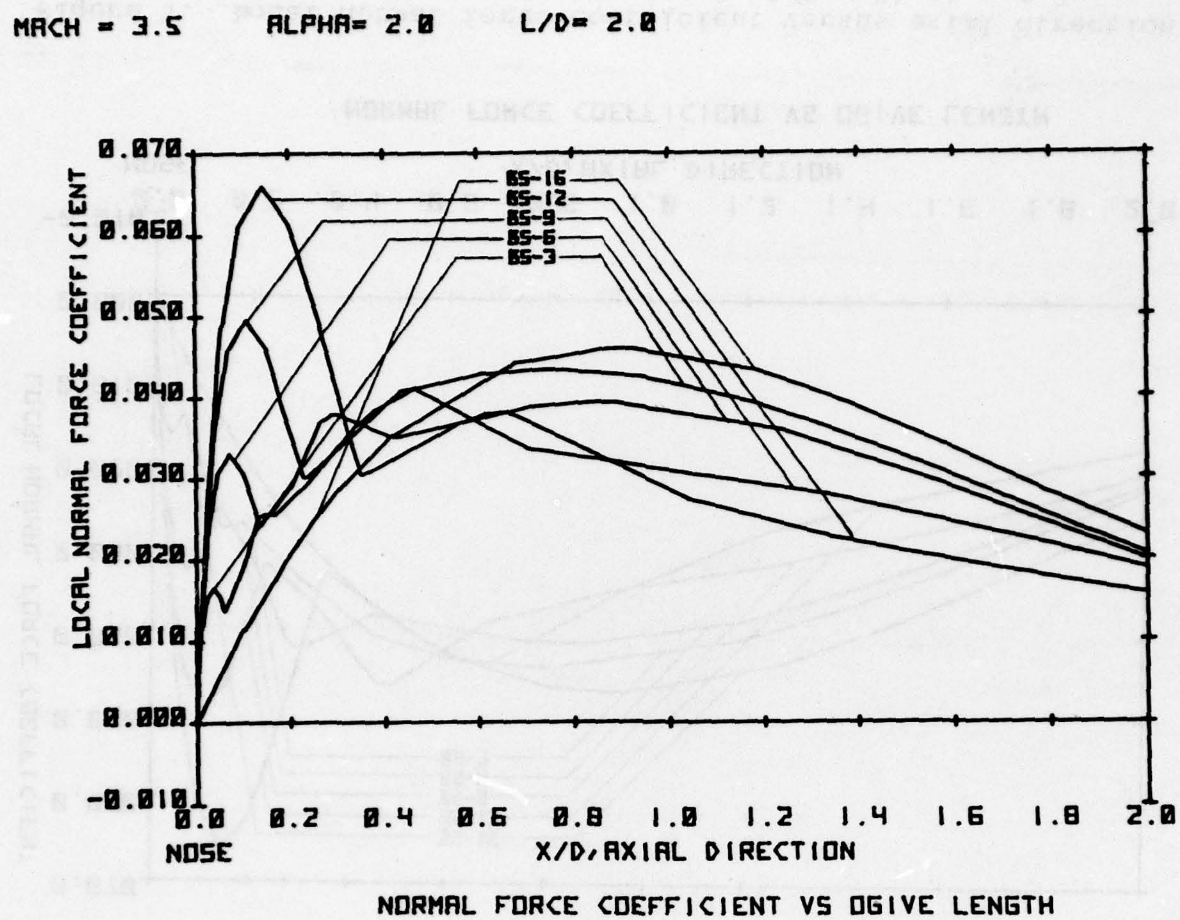


Figure 3. Local normal force coefficient versus axial direction (BS = 3, 6, 9, 12, 16; M = 3; L/D = 2) at α = 2.



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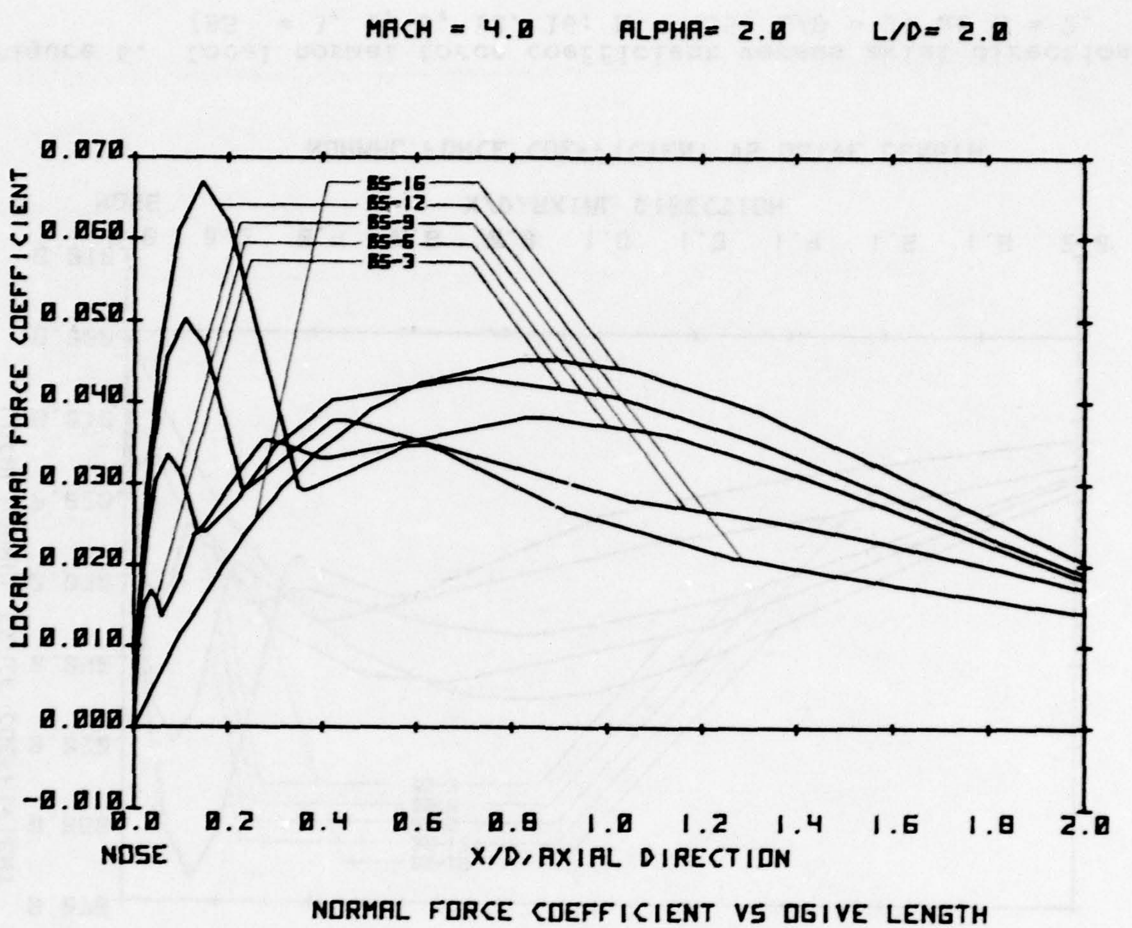

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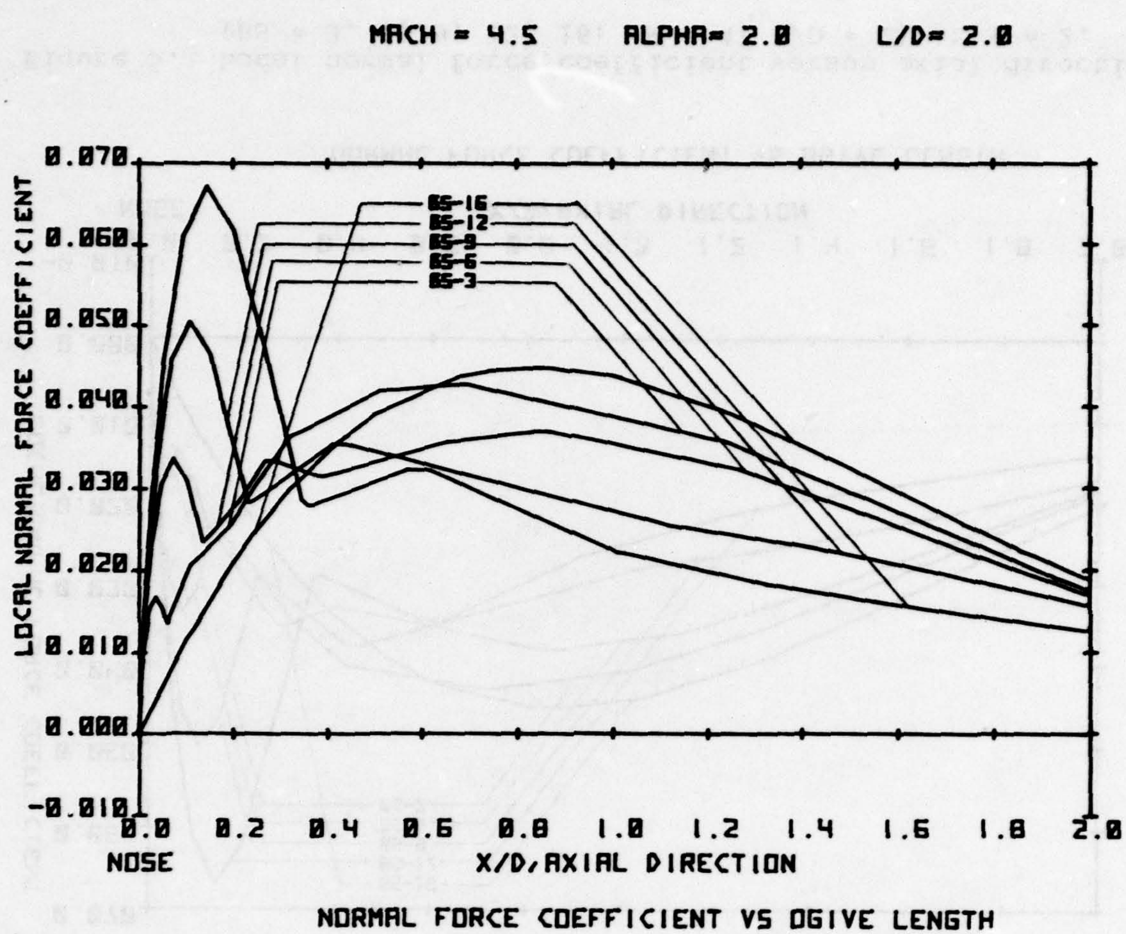

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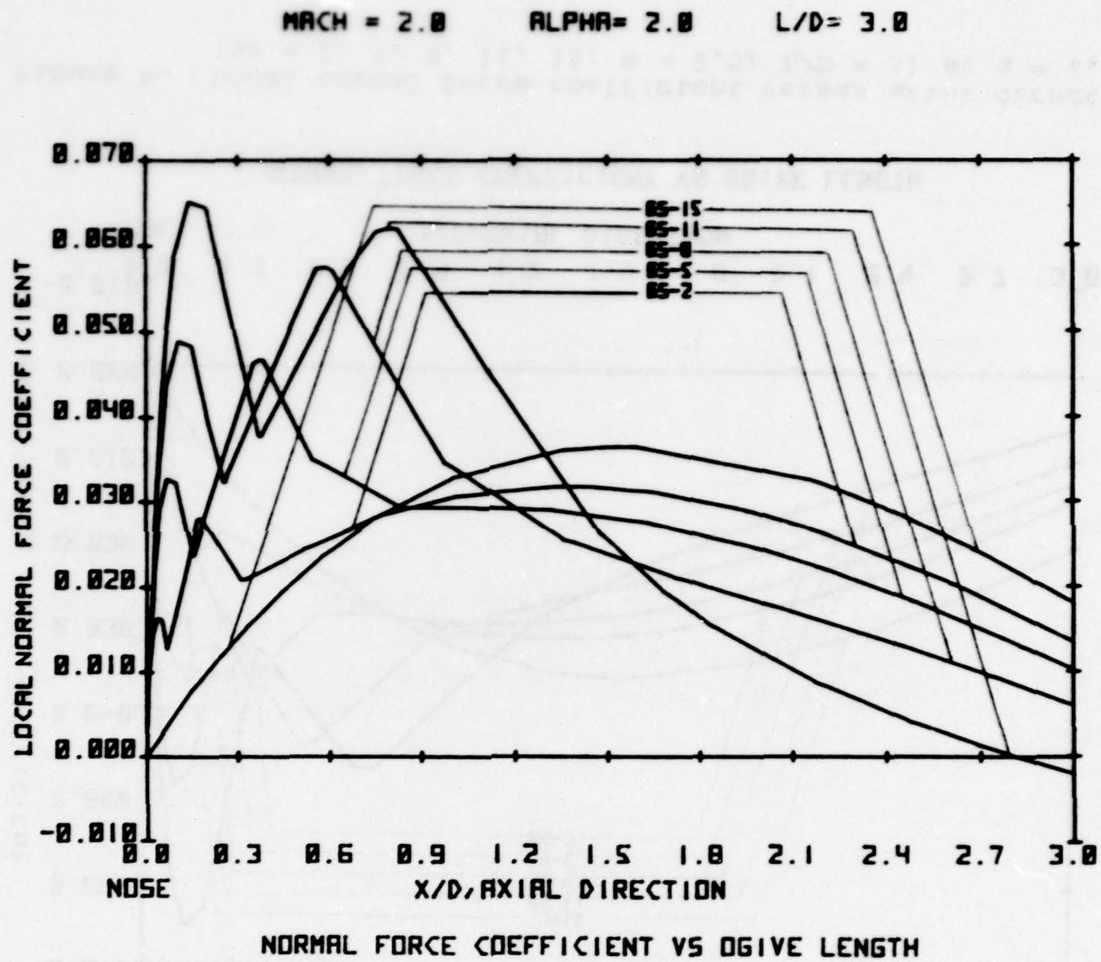

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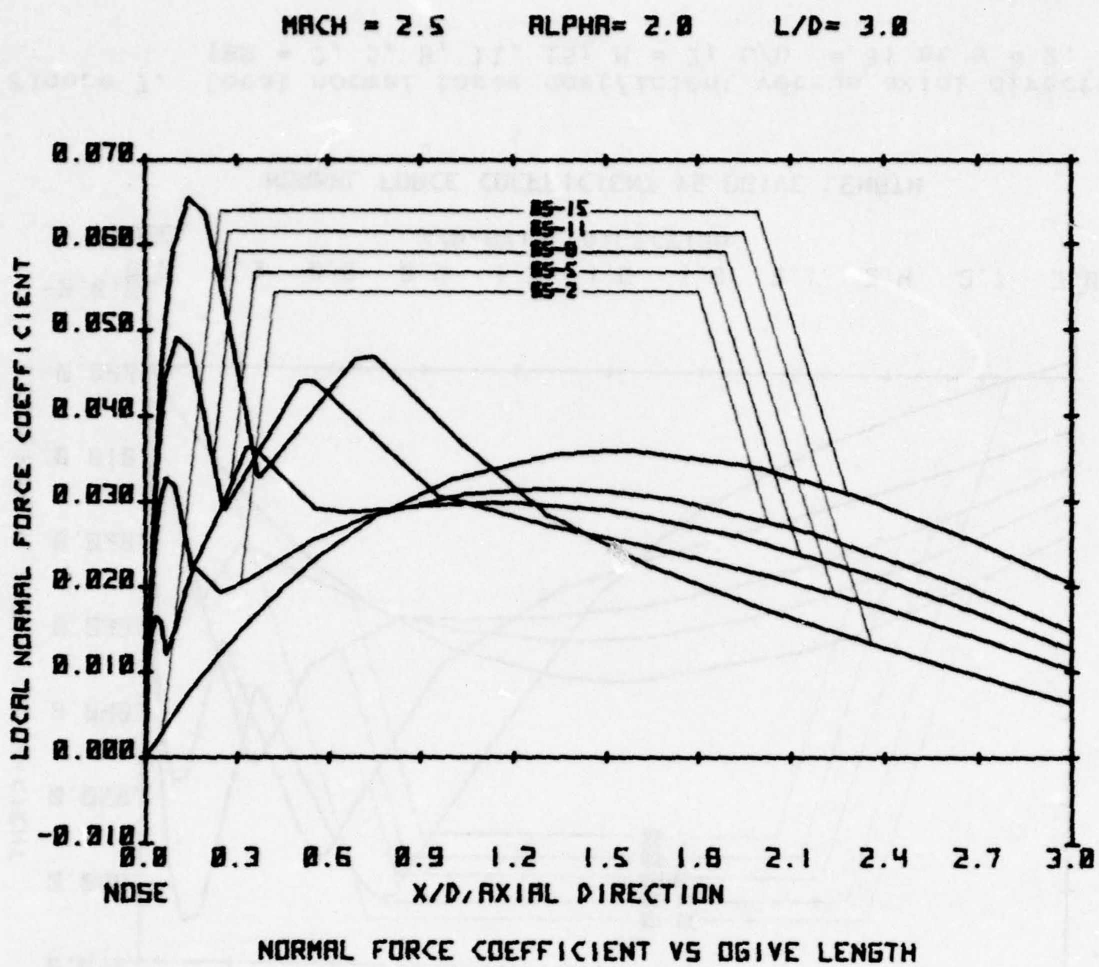

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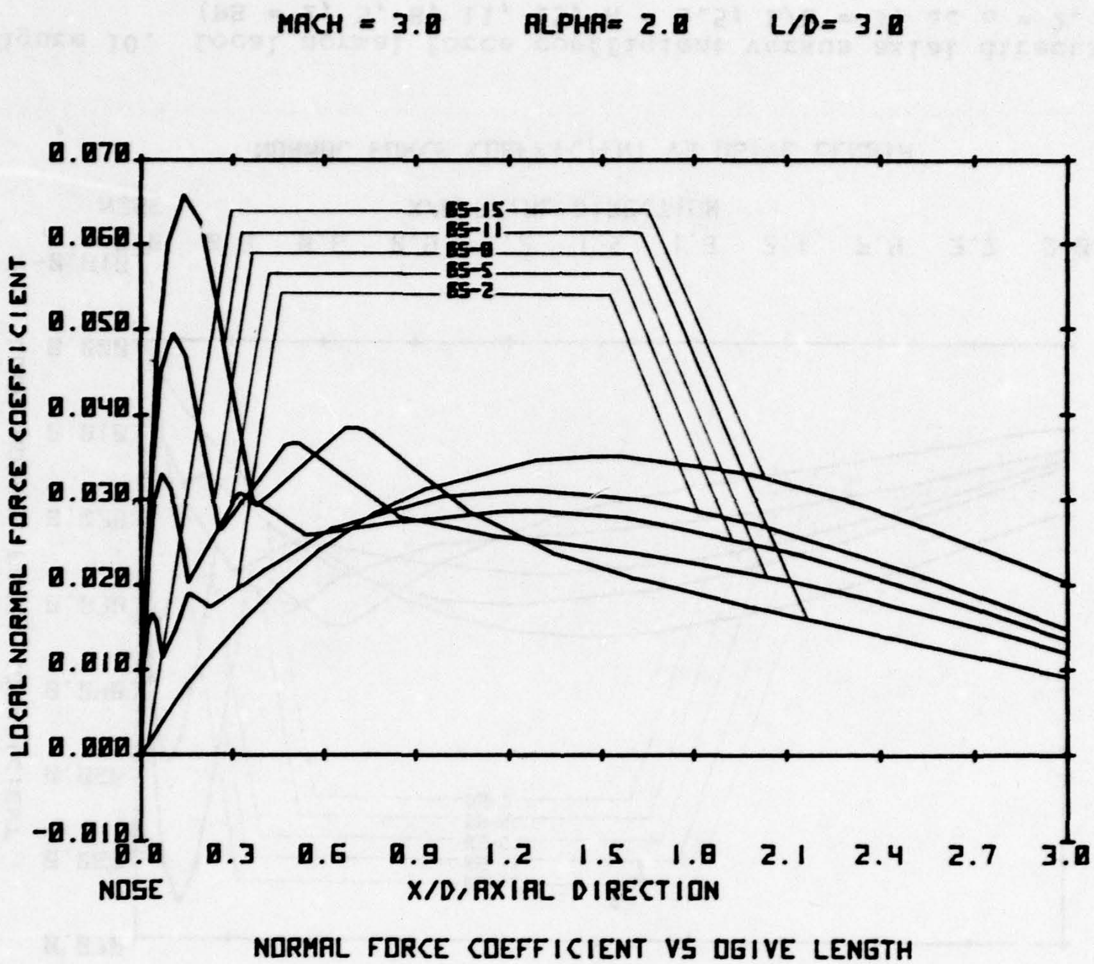

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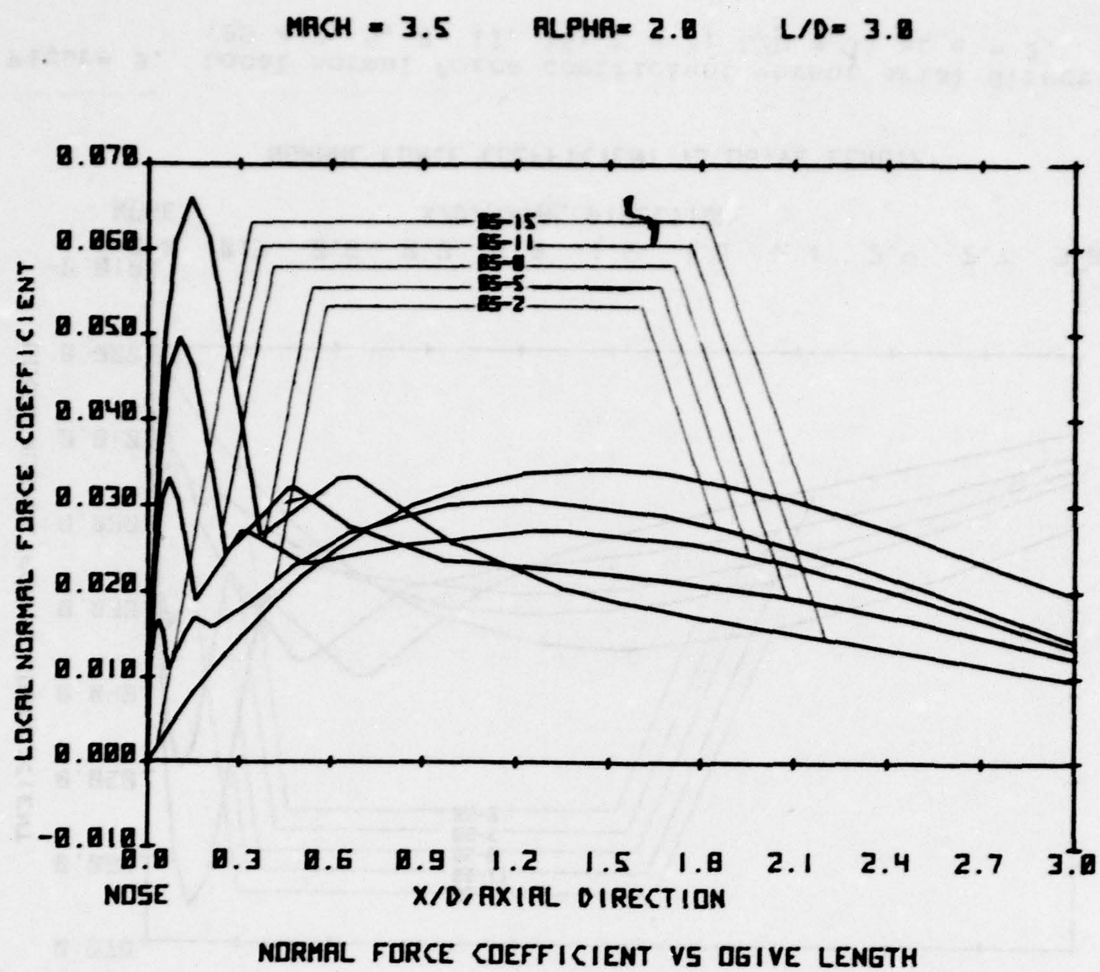

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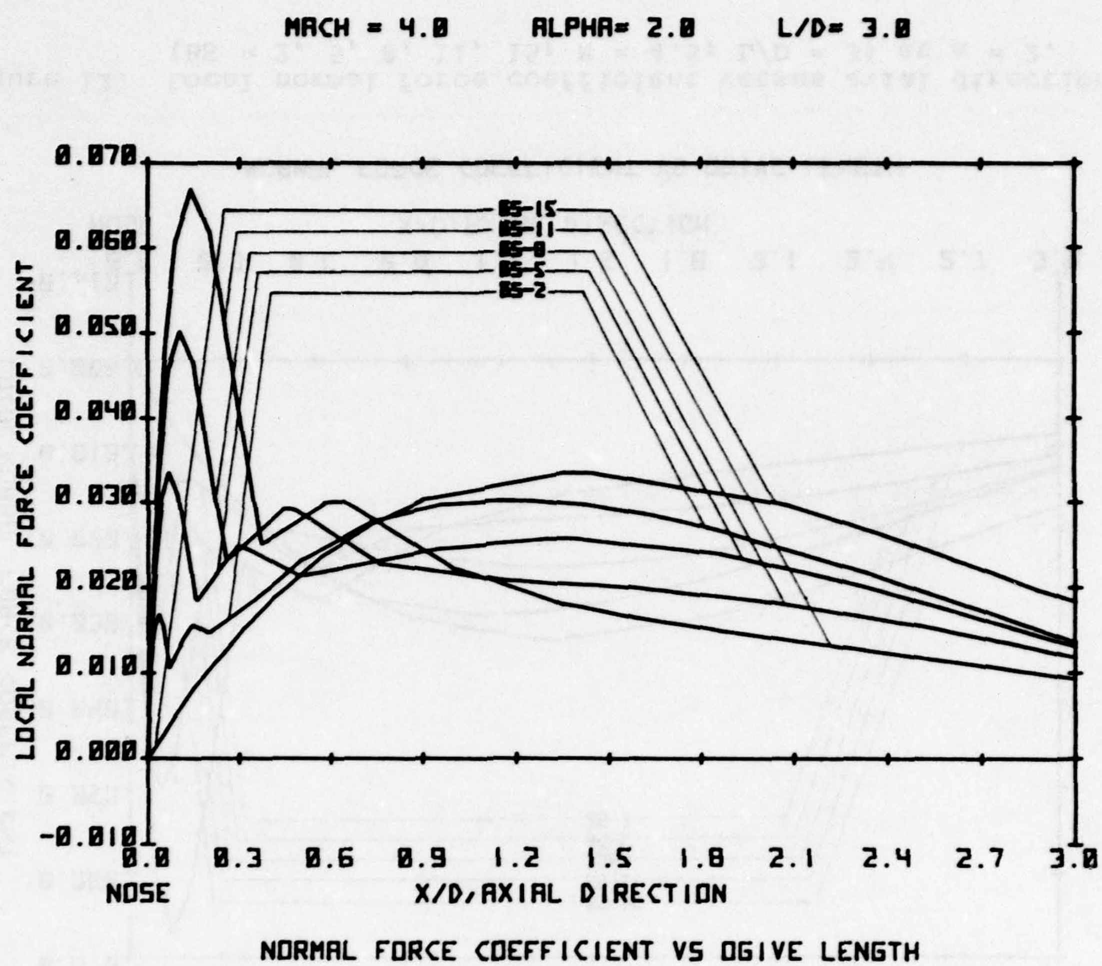

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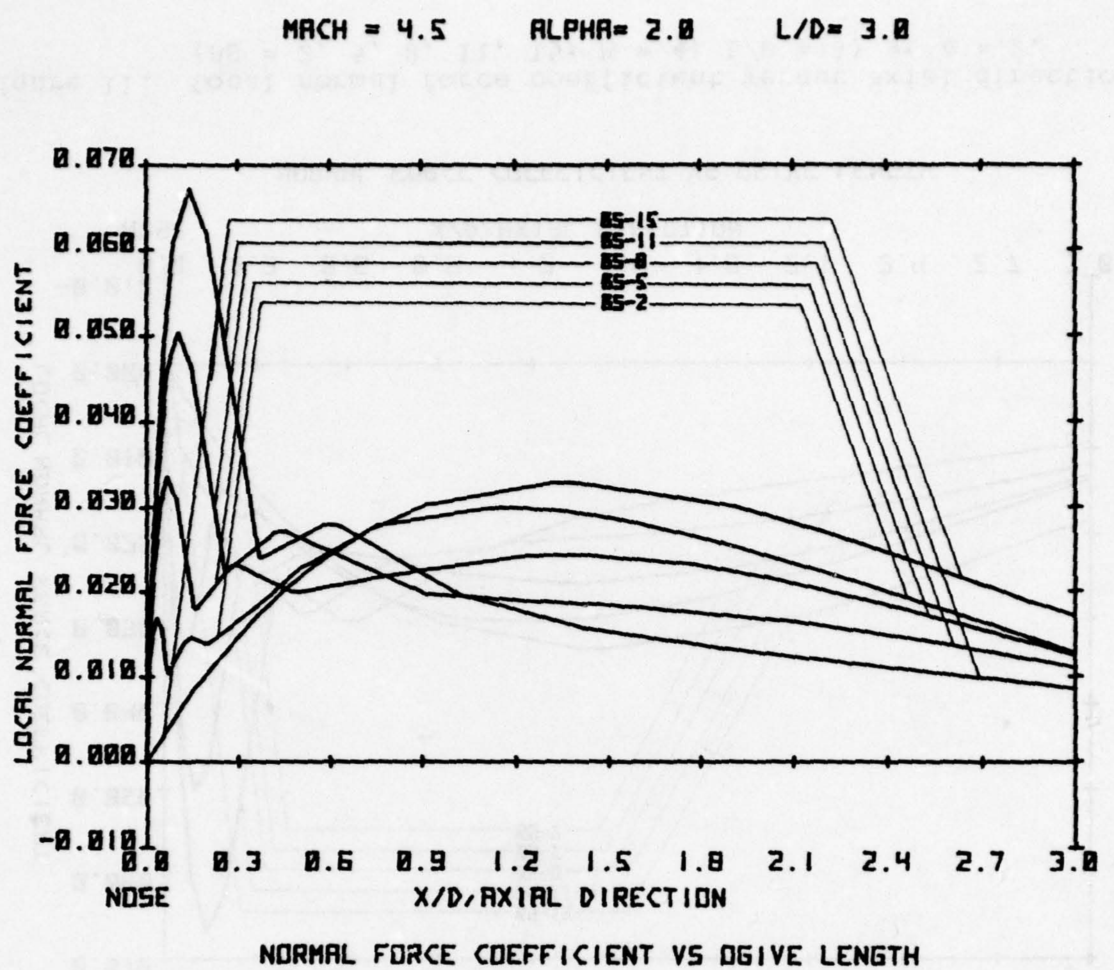

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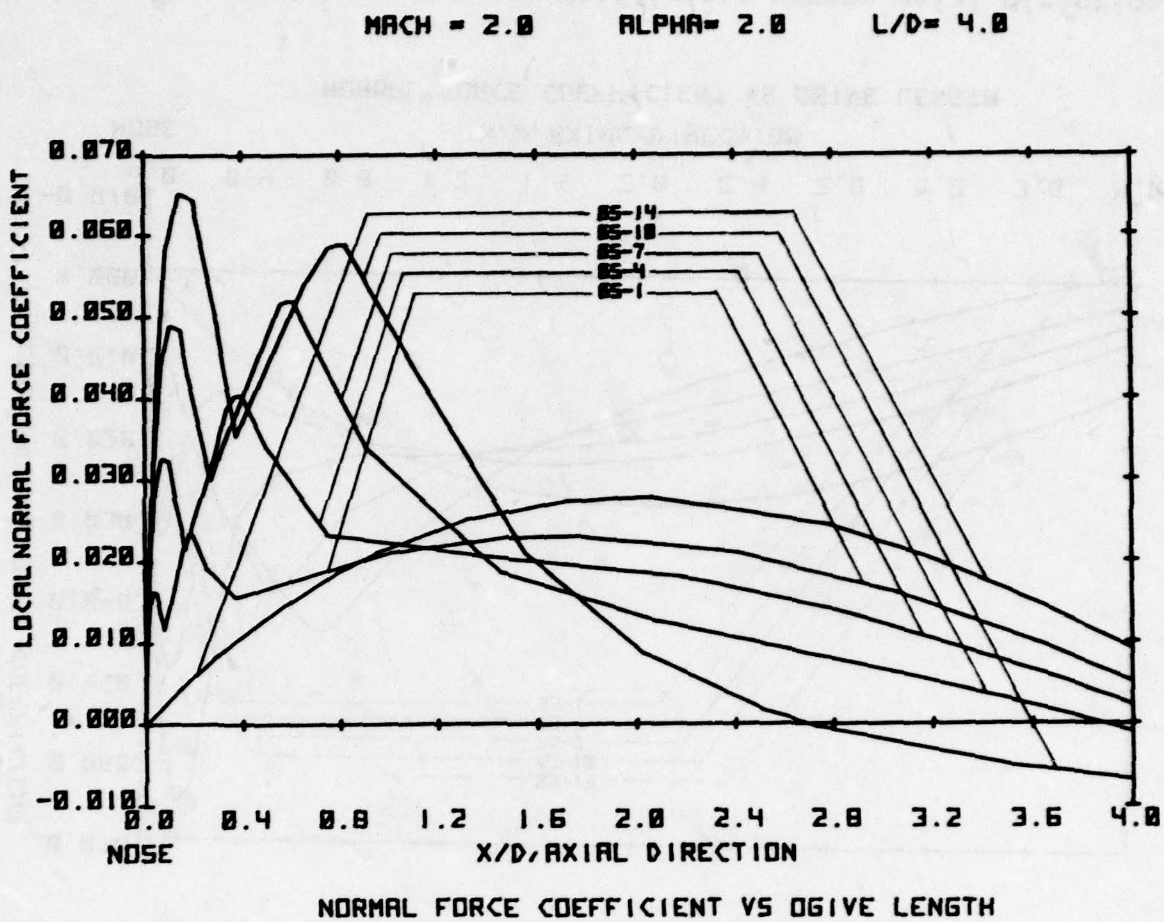

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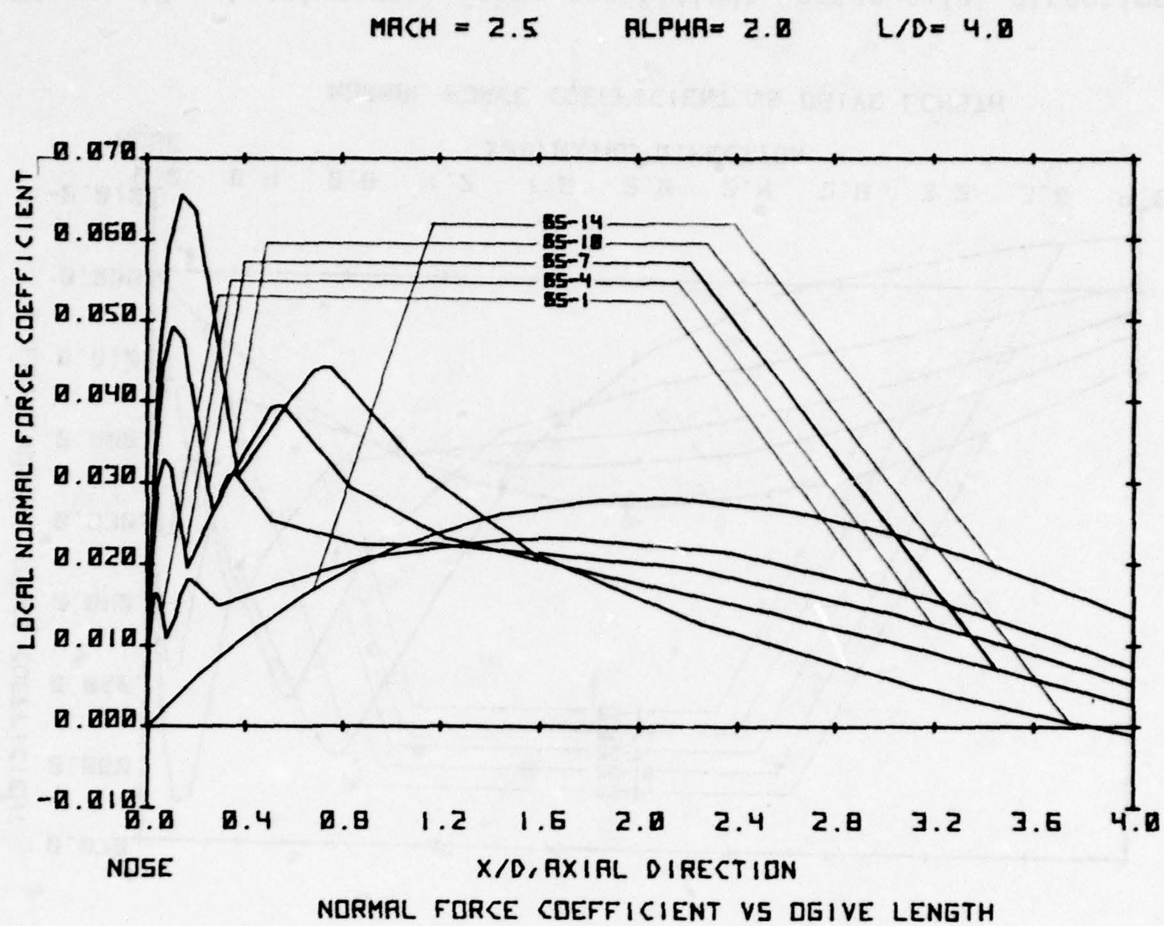

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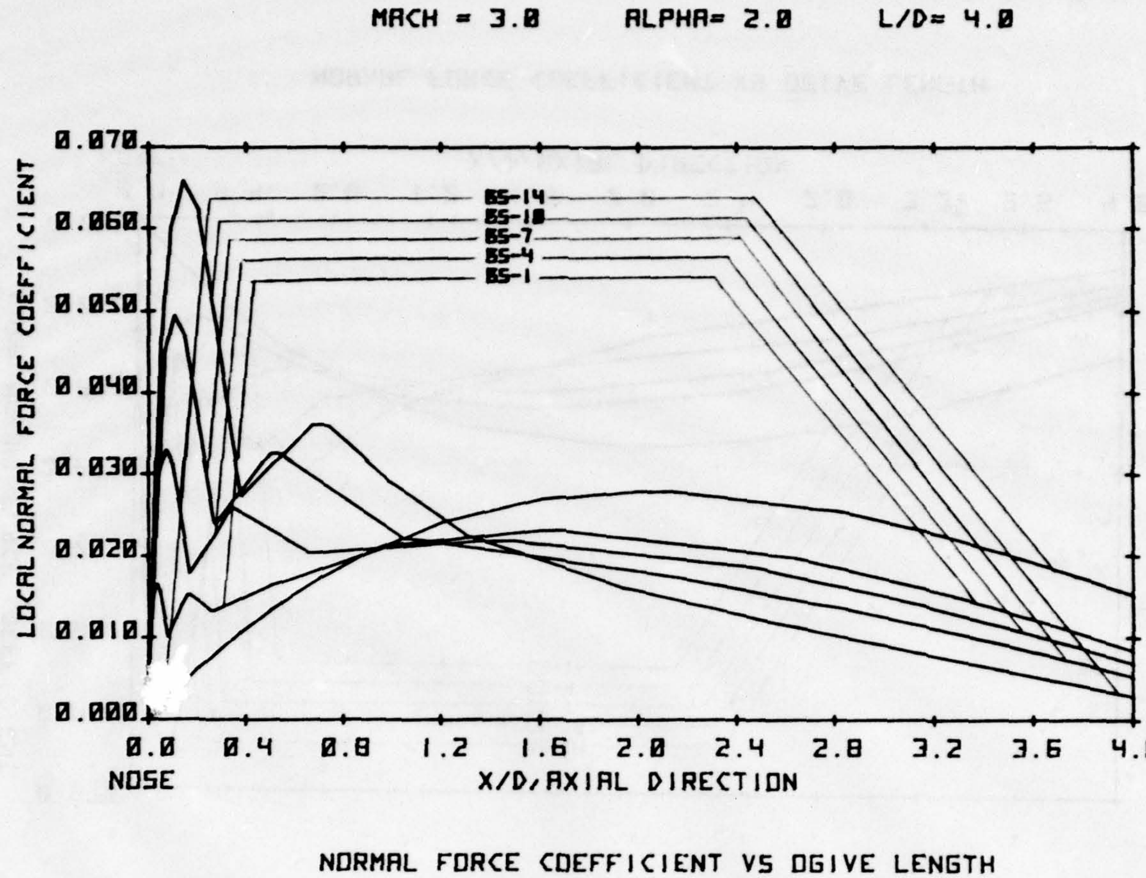

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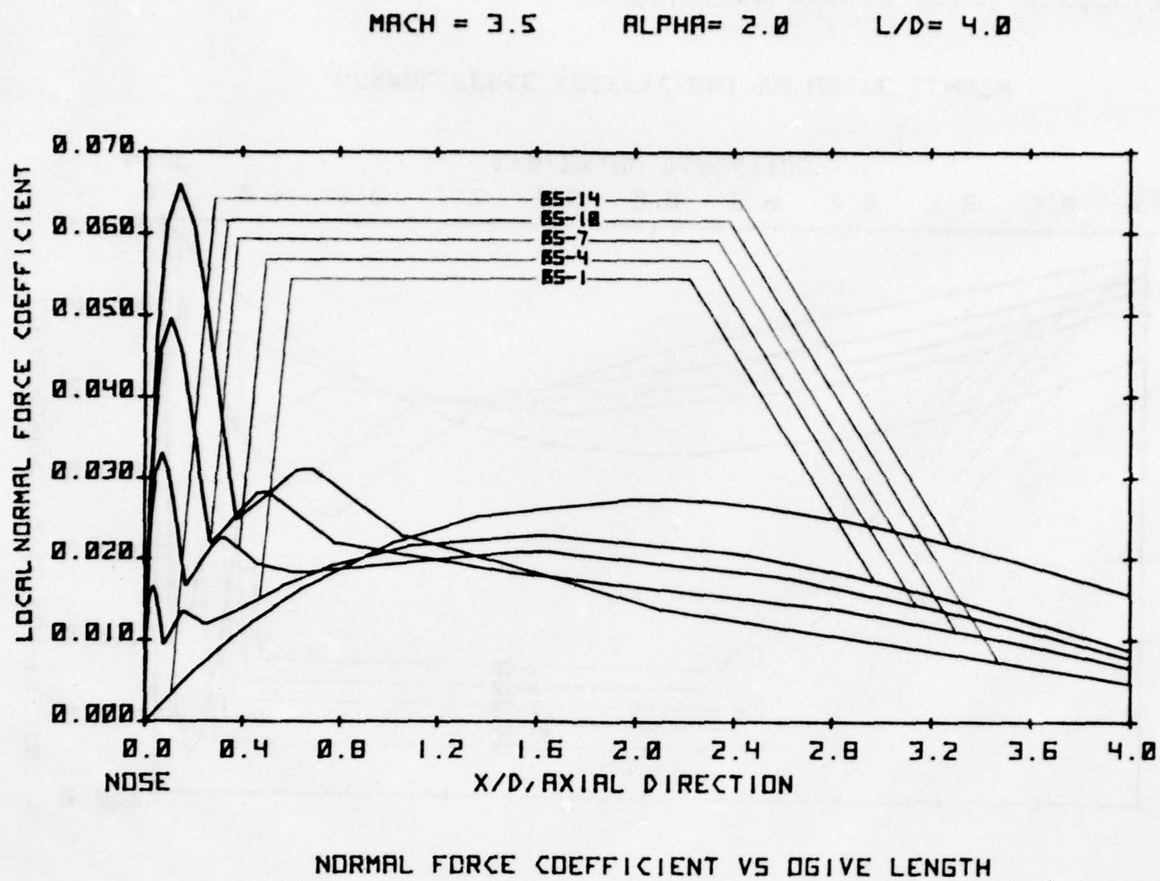

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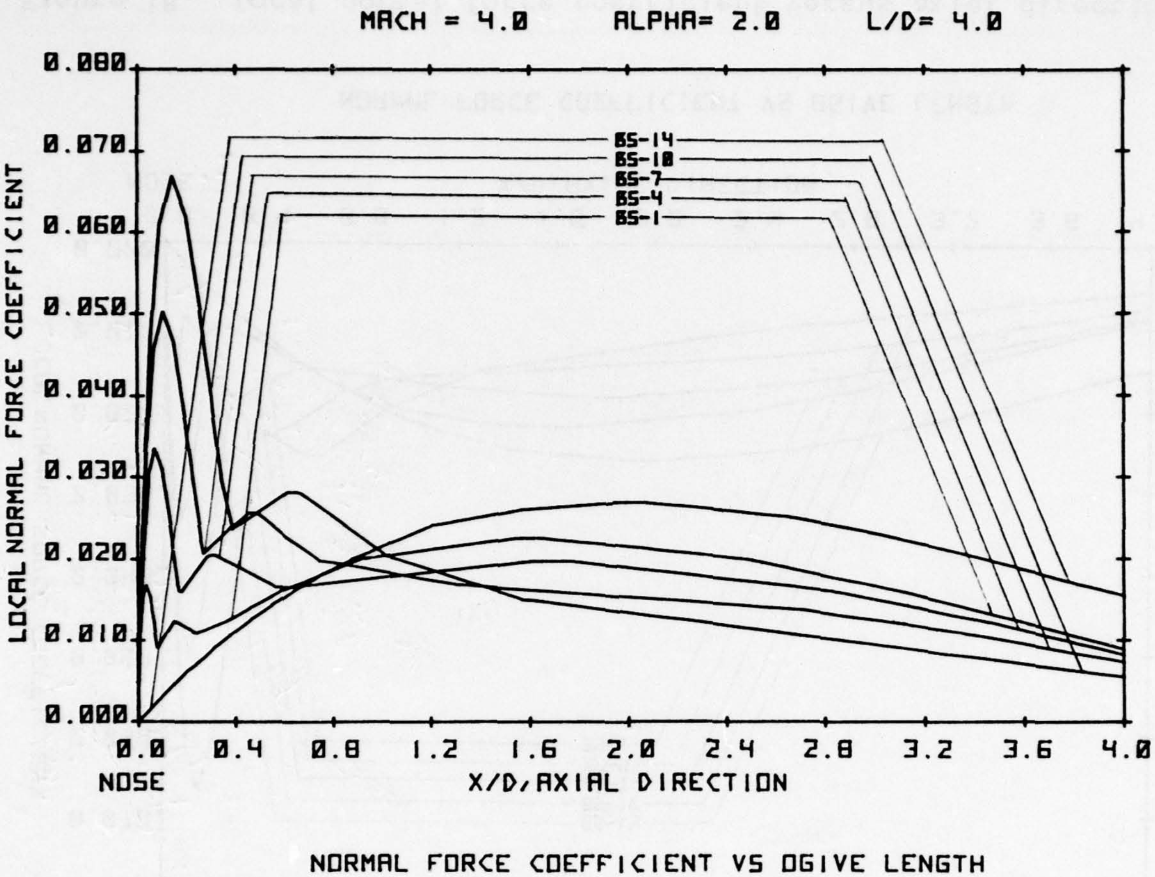

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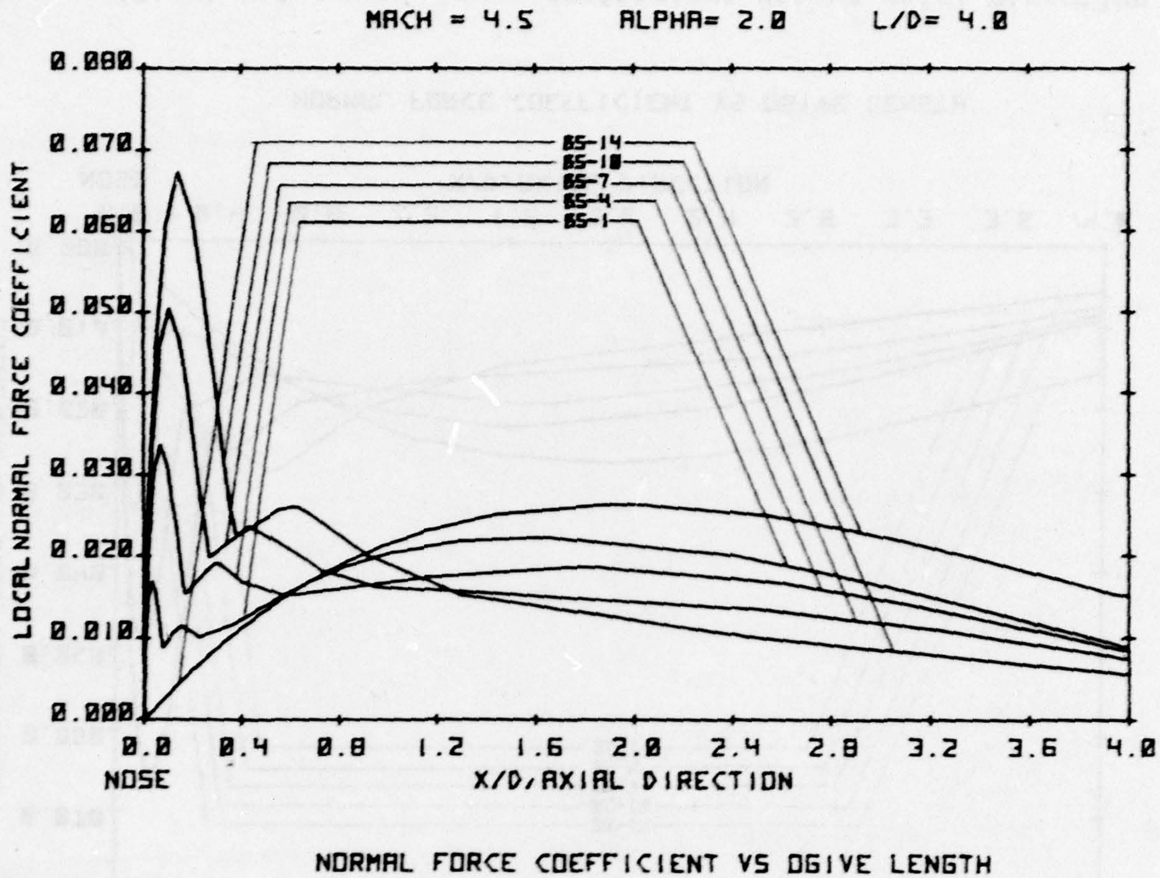

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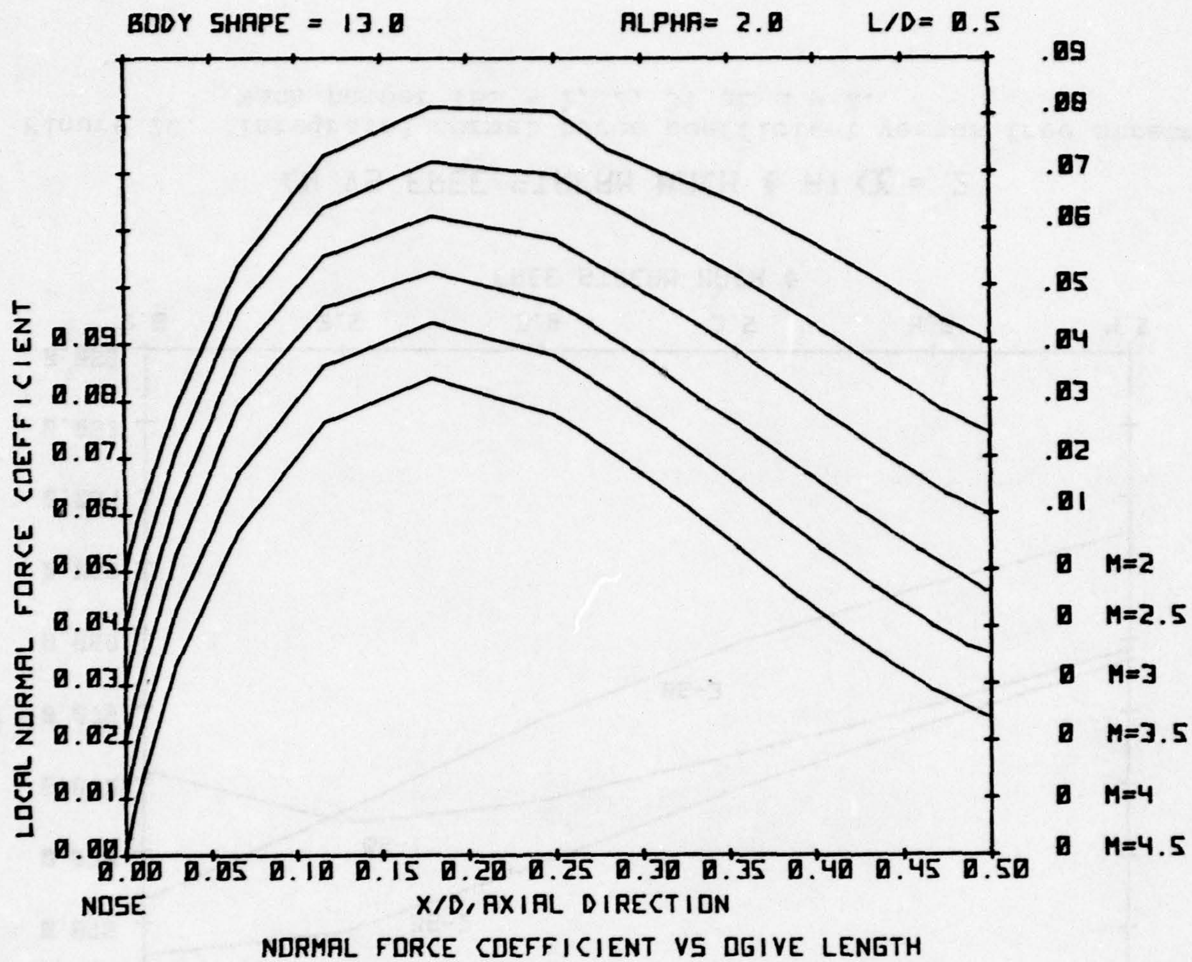

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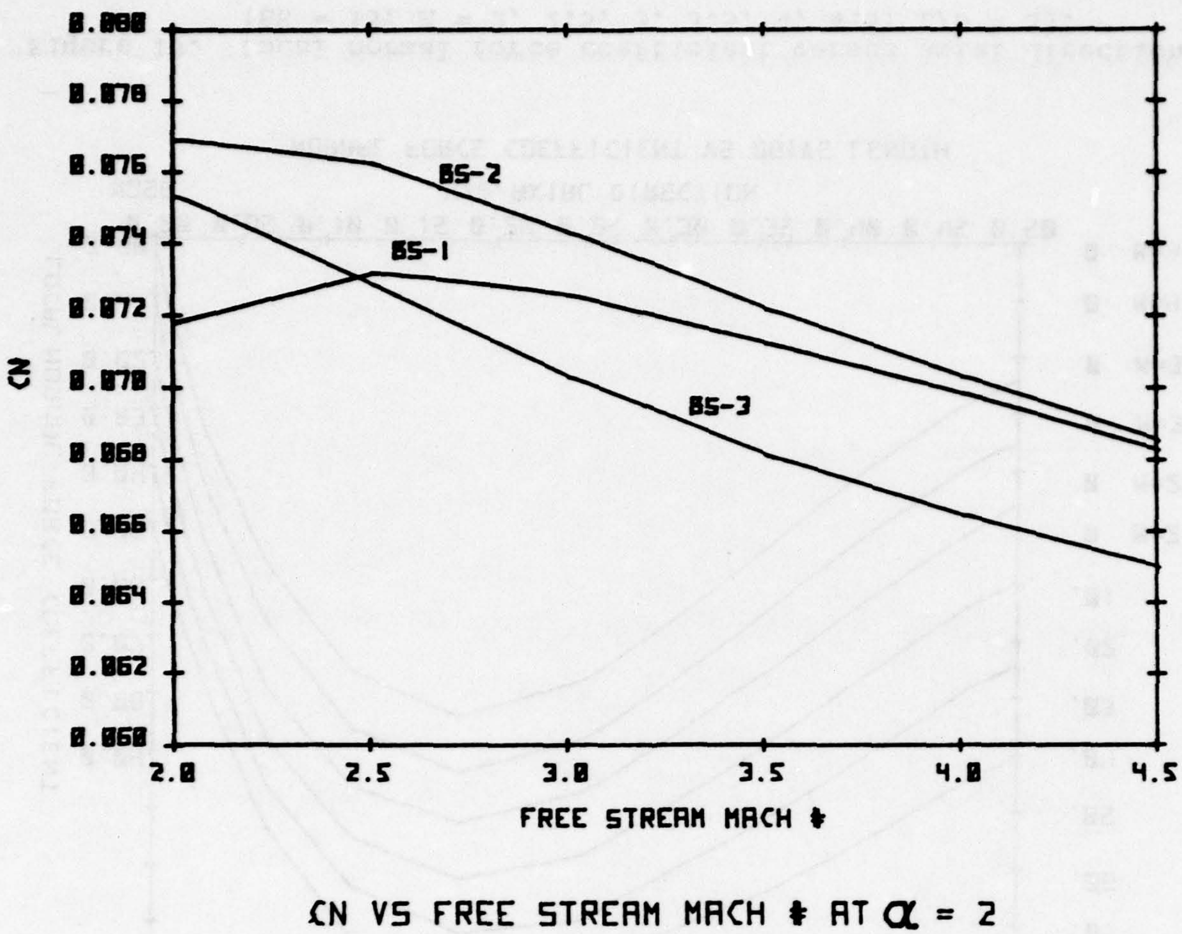

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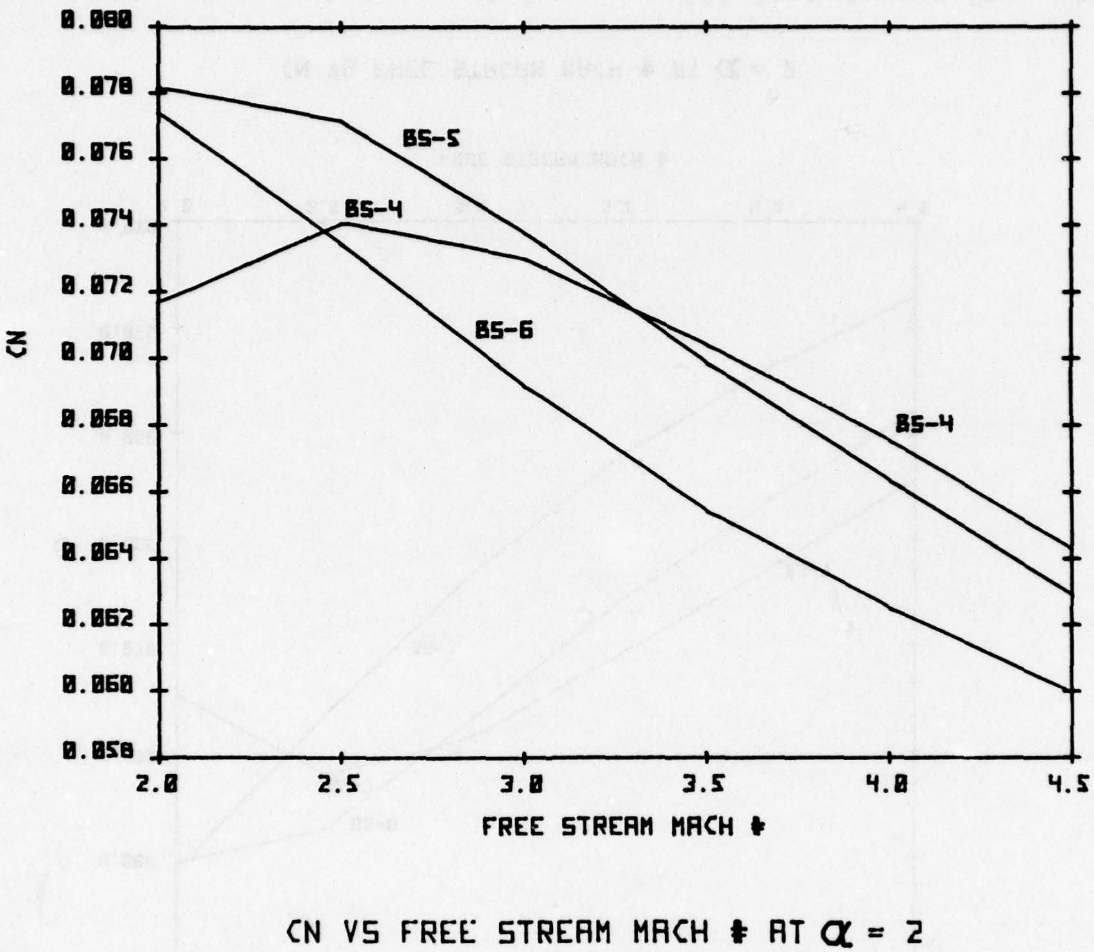

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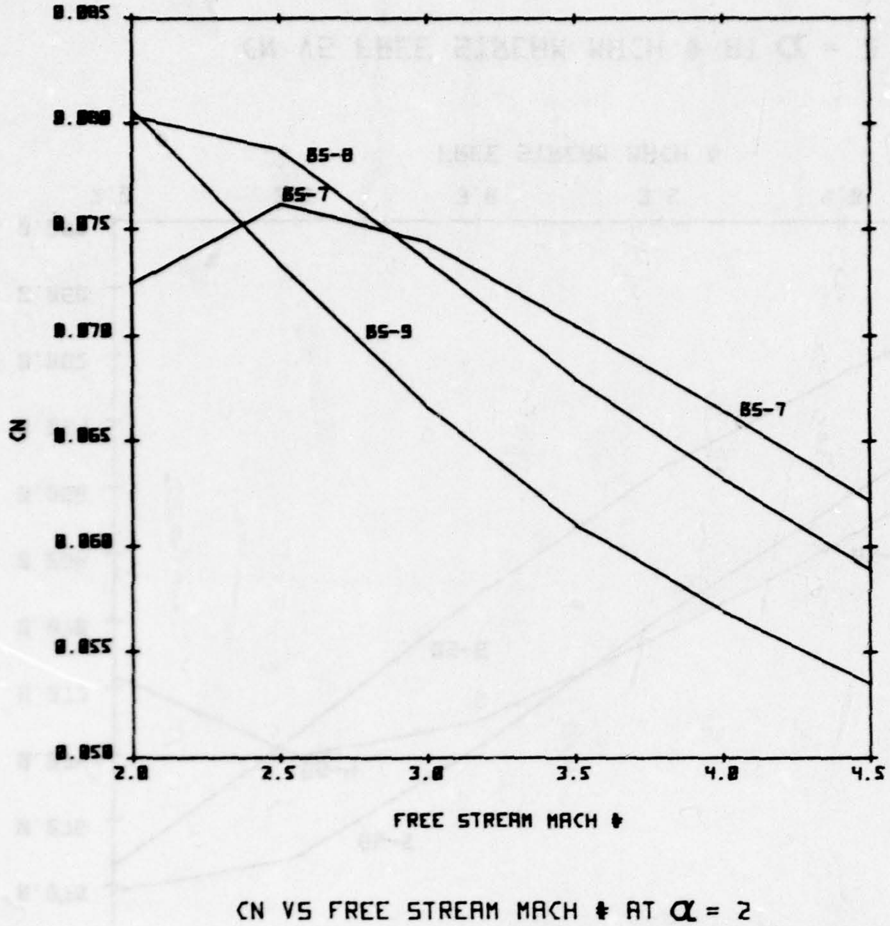

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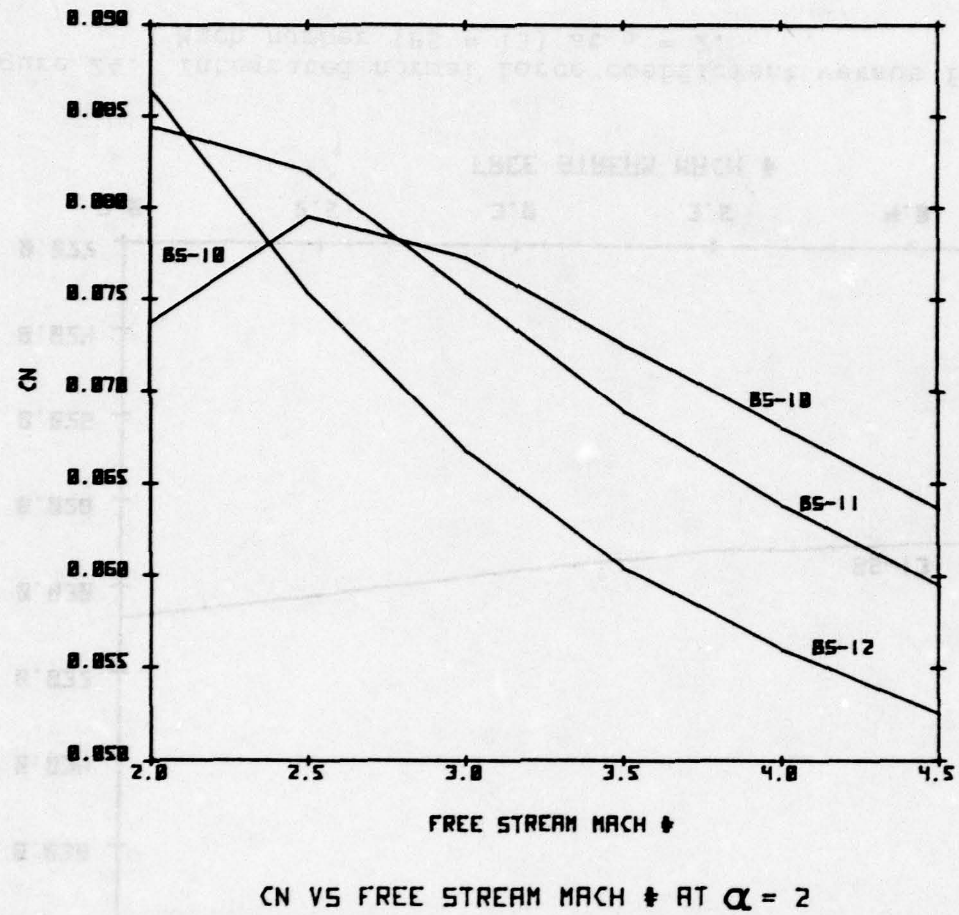

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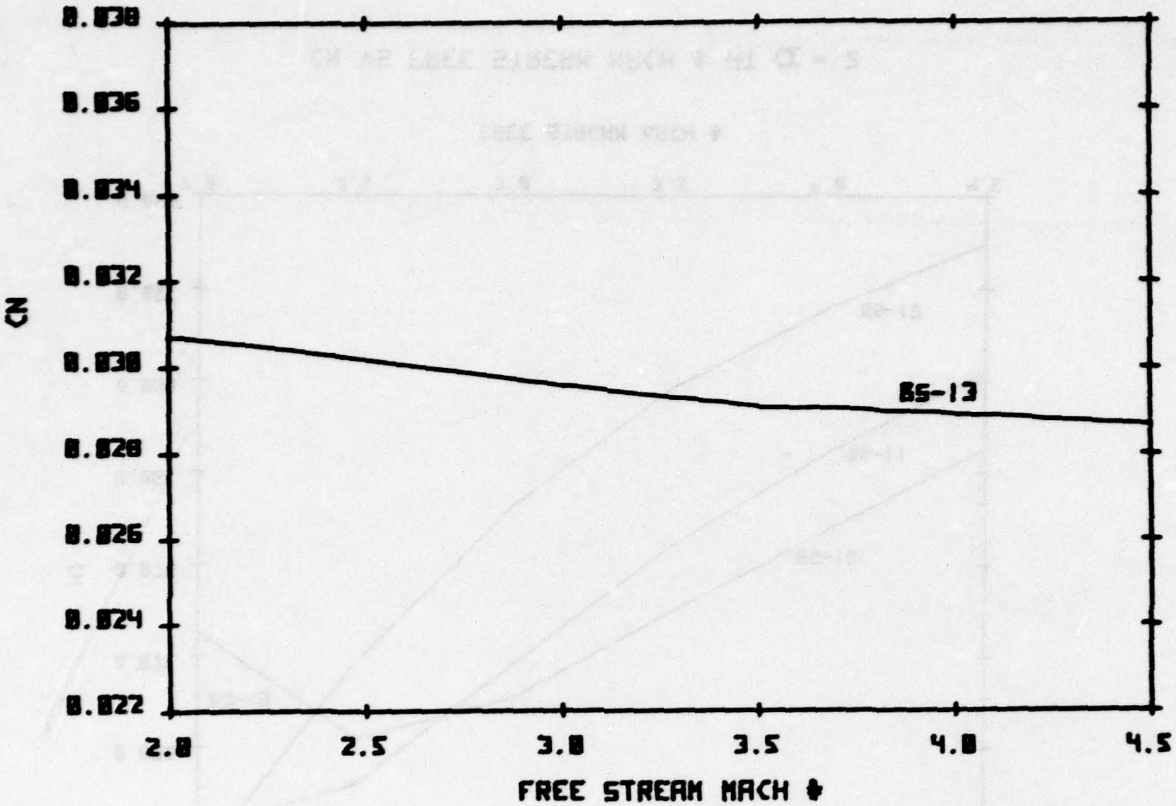

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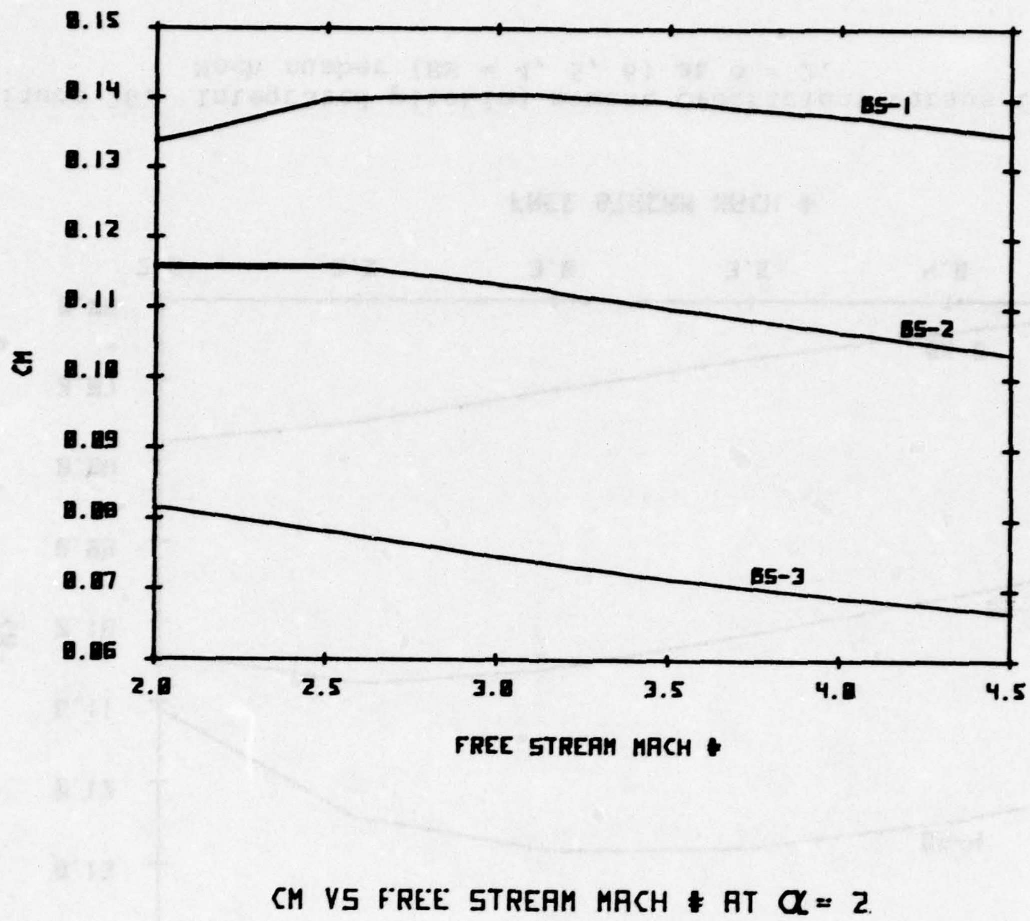

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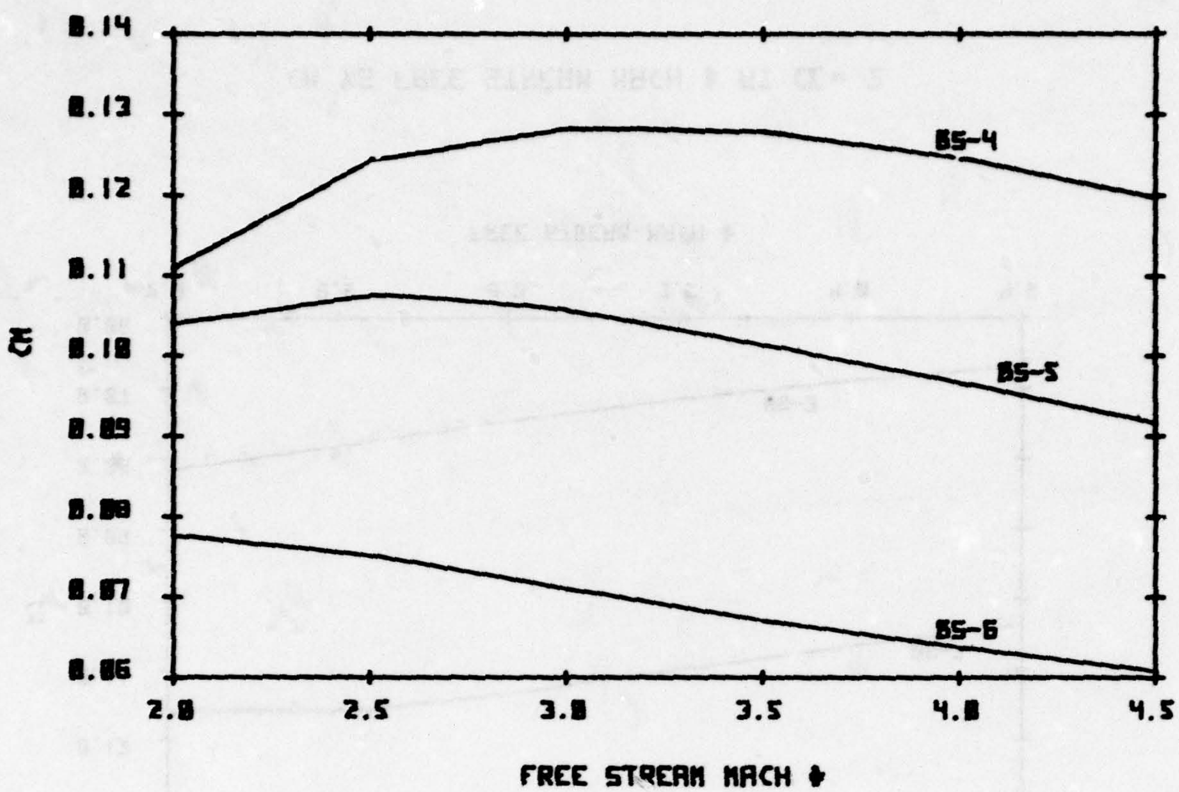

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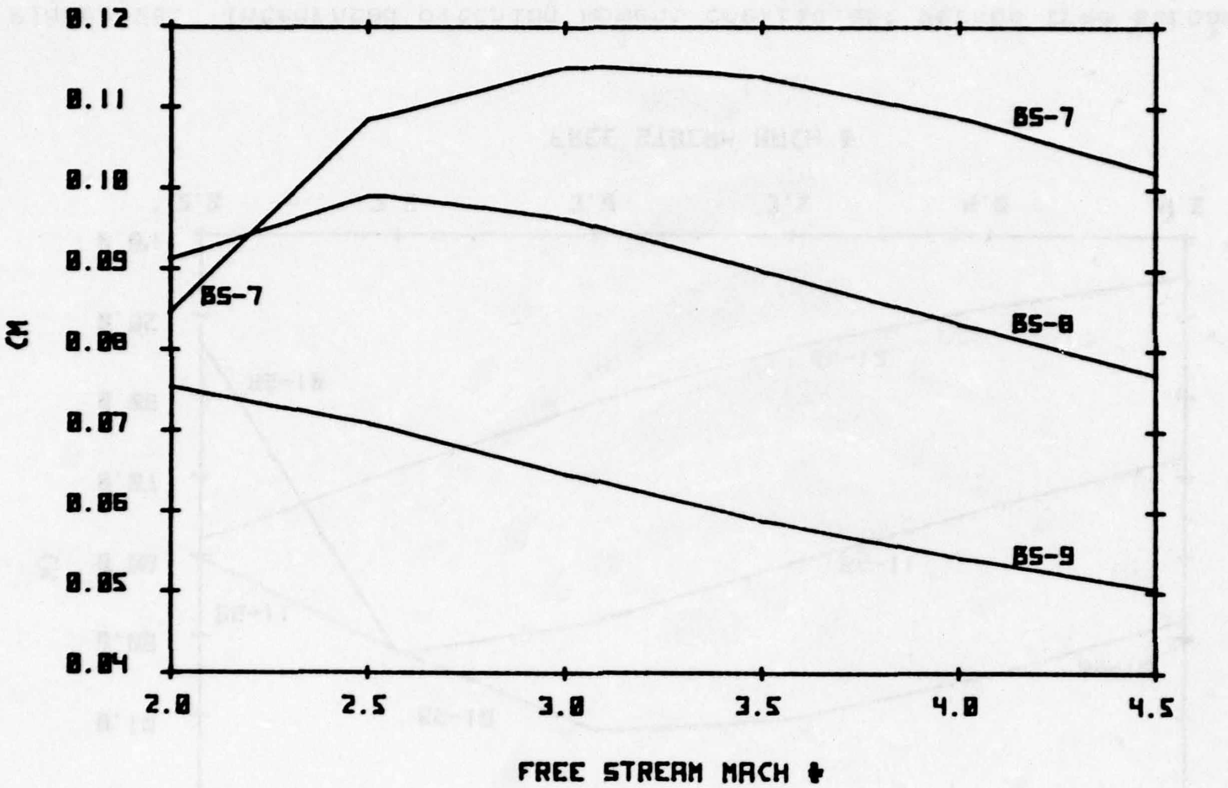

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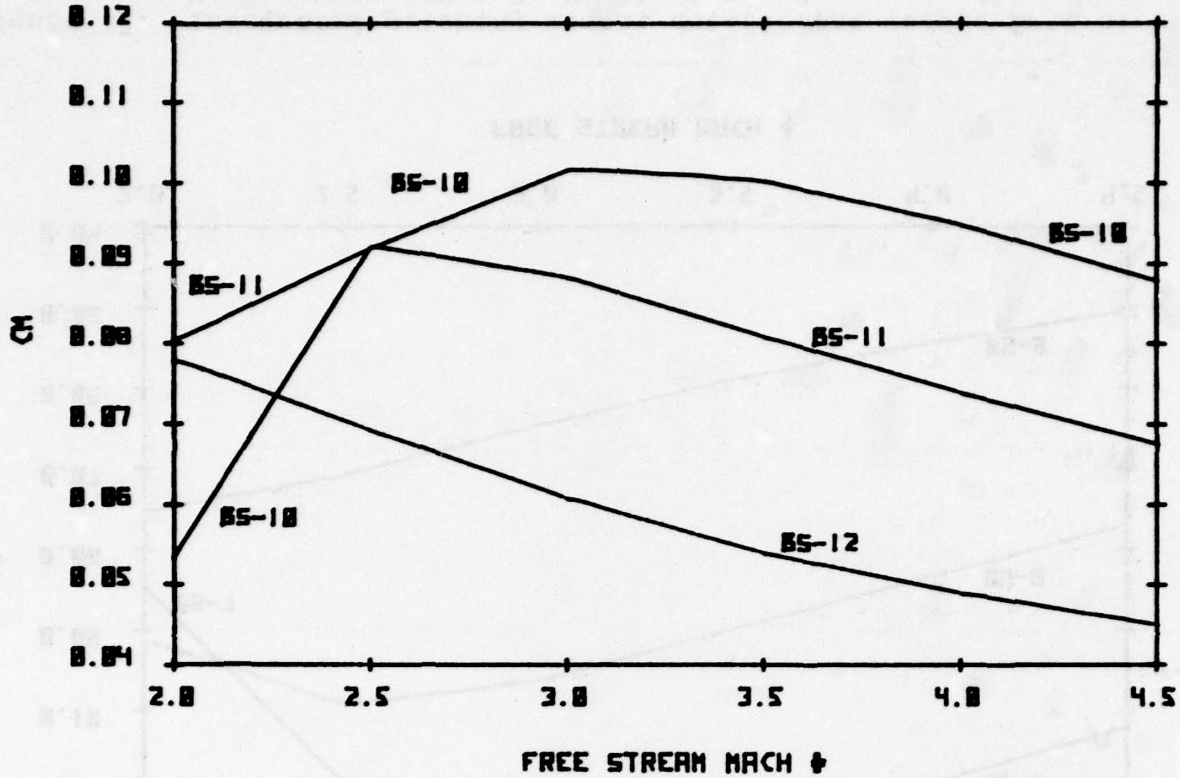

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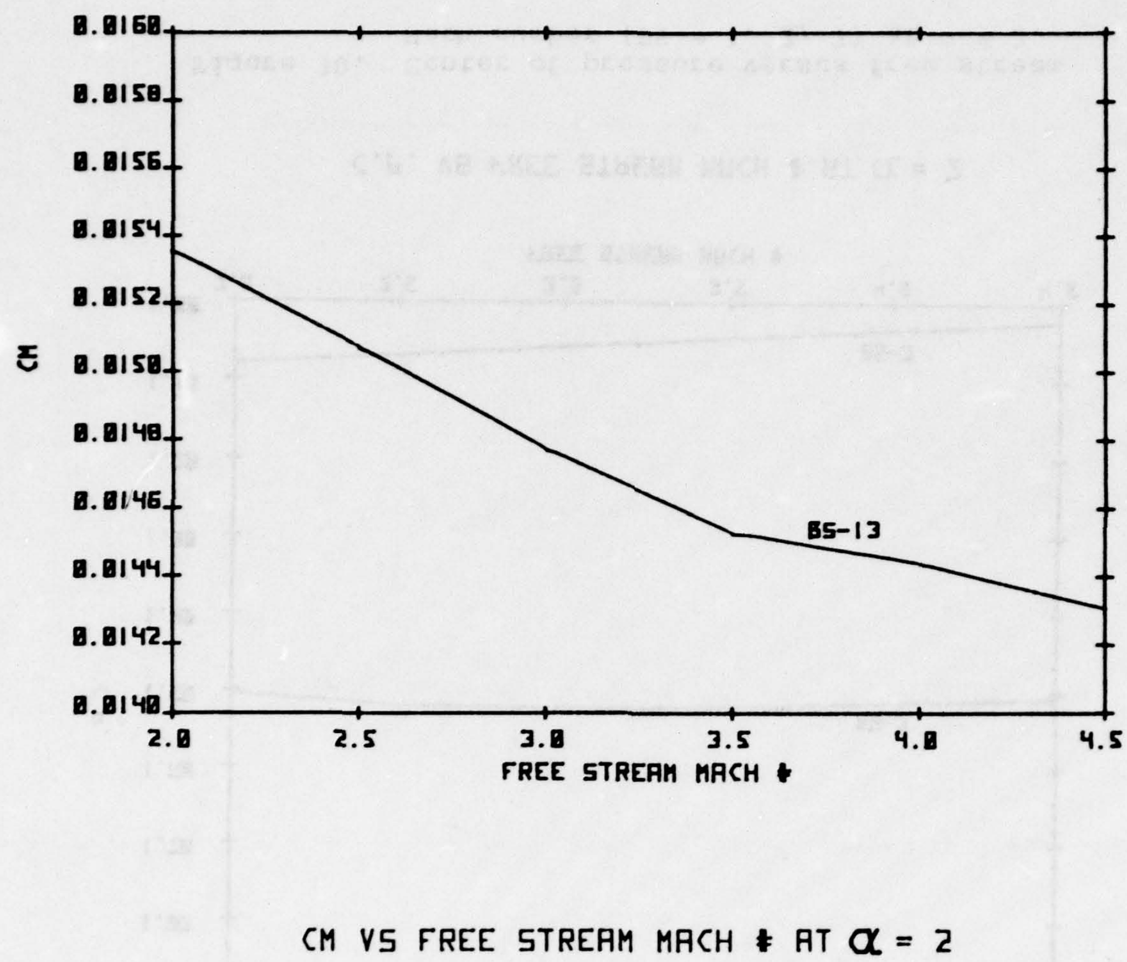

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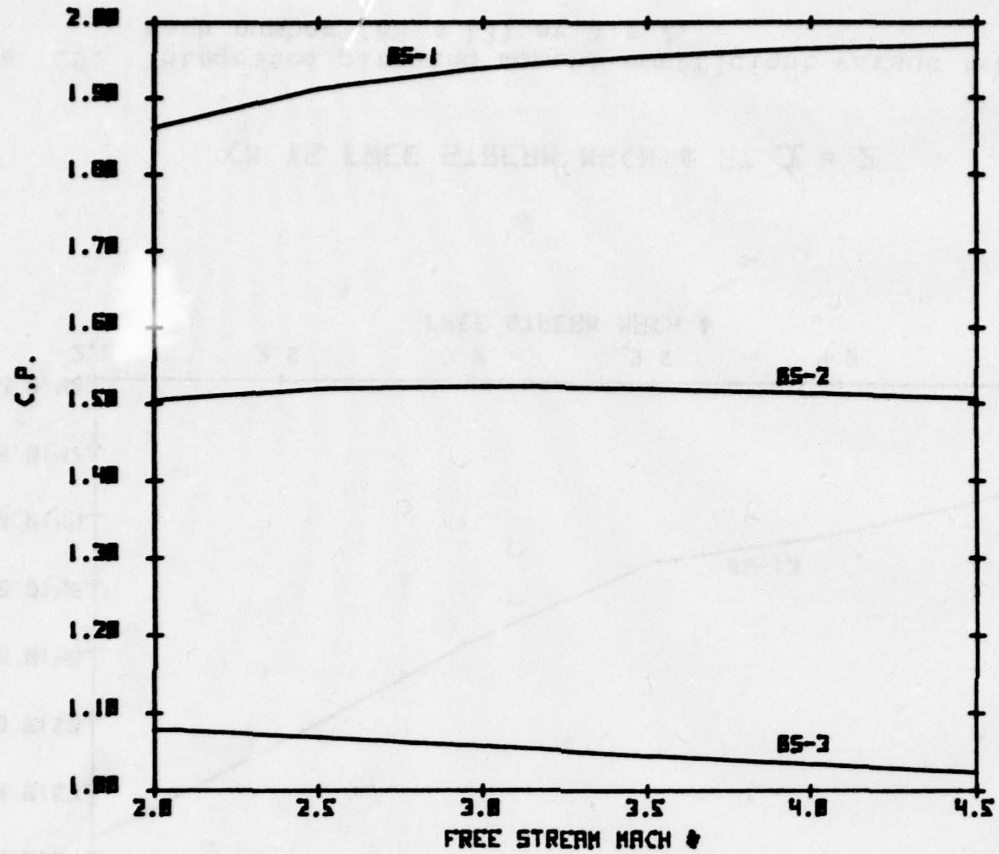

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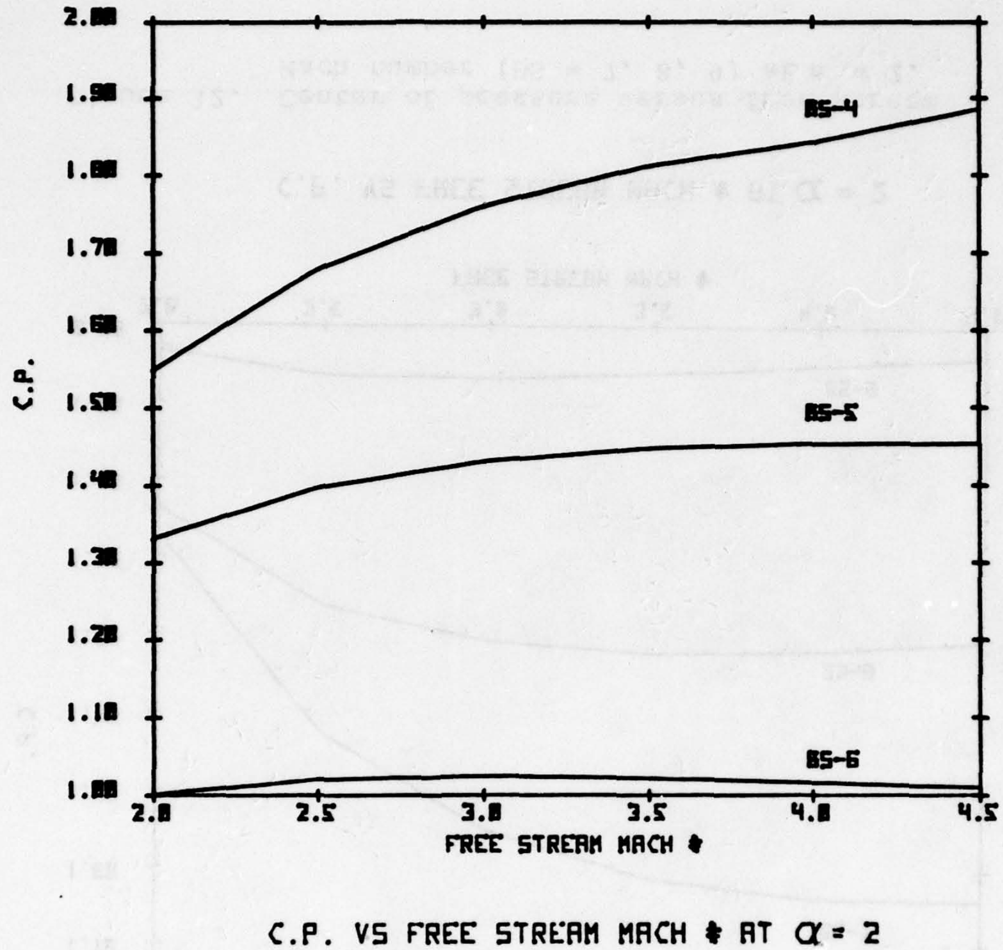

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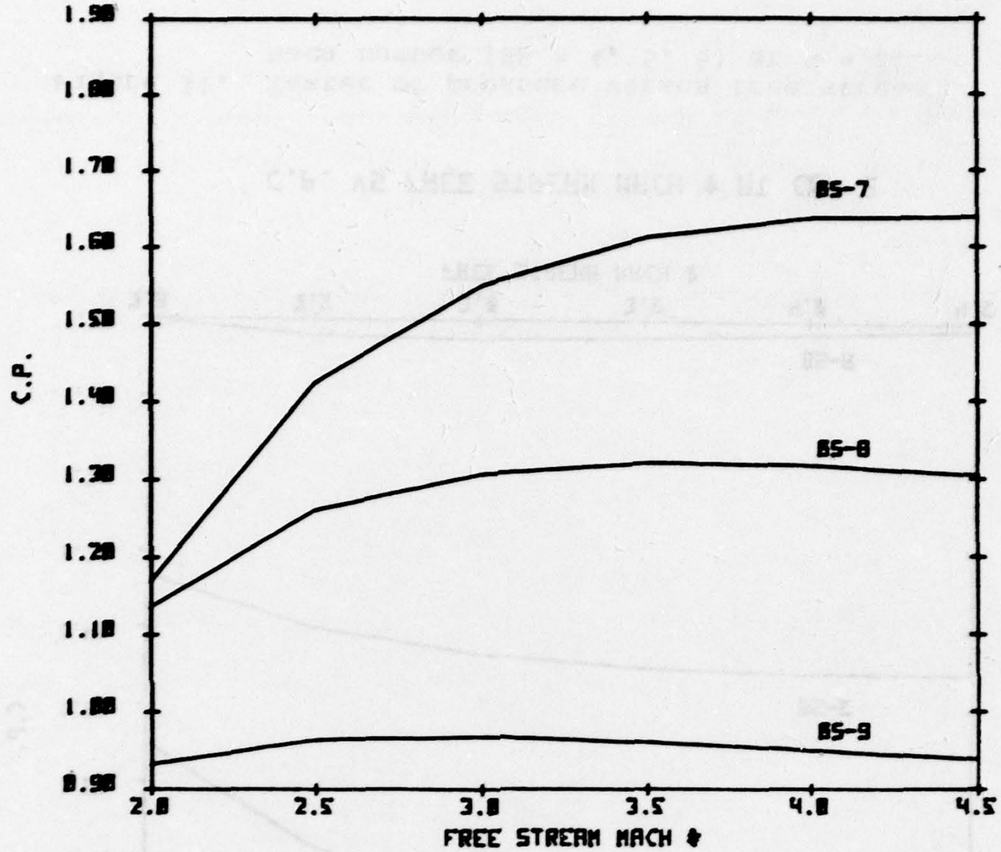
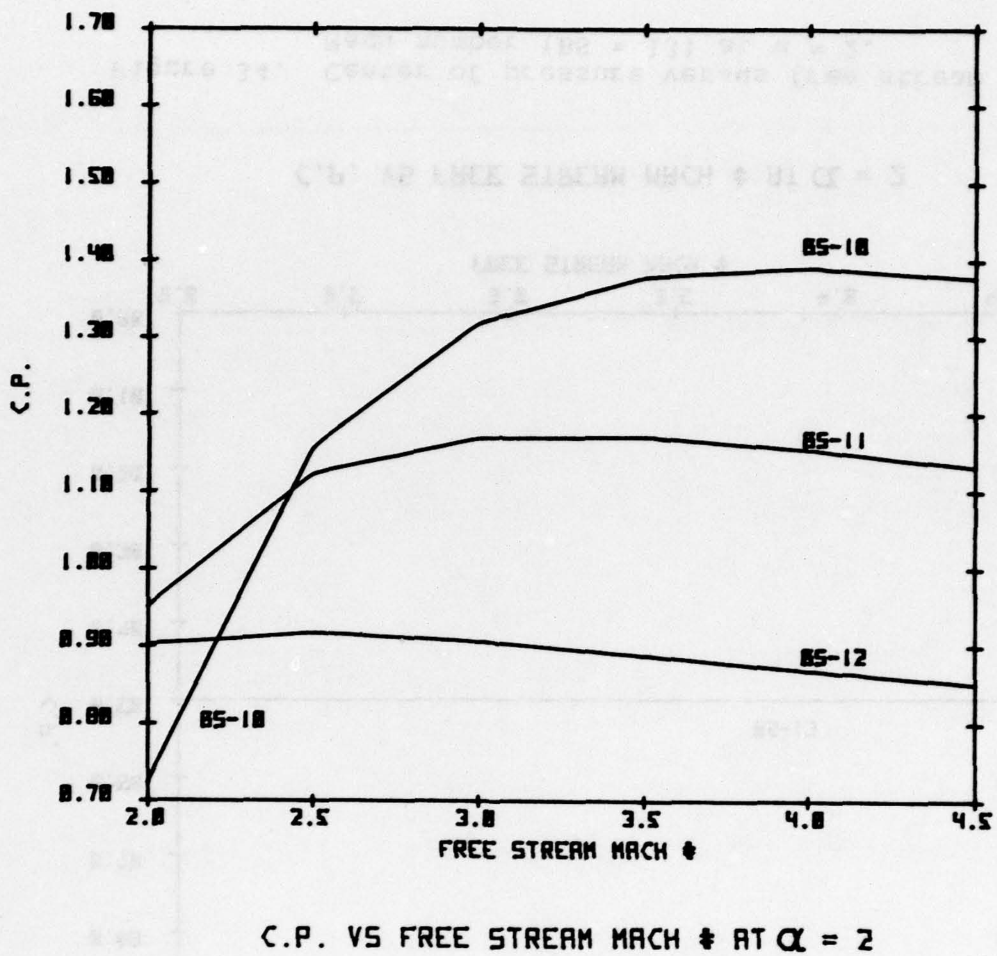


C.P. VS FREE STREAM MACH # AT α = 2

Figure 32. Center of pressure versus free stream Mach number (BS = 7, 8, 9) at α = 2.



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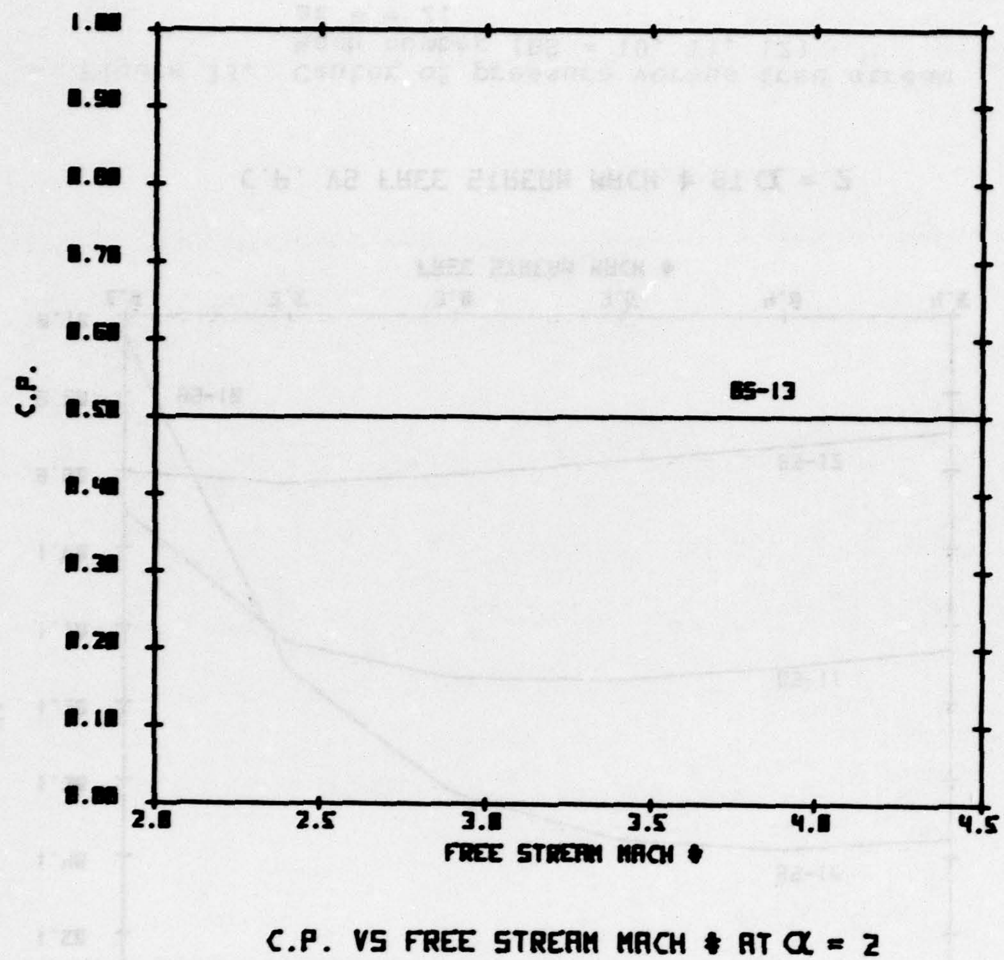

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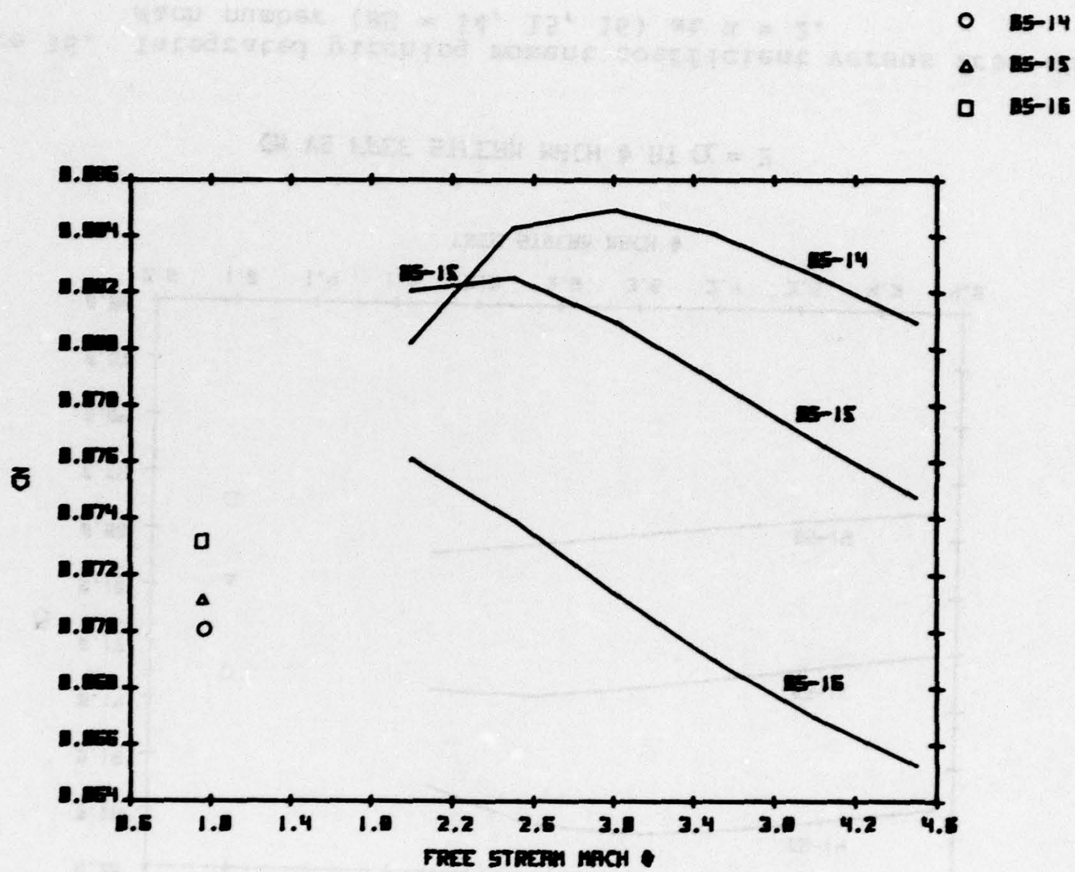
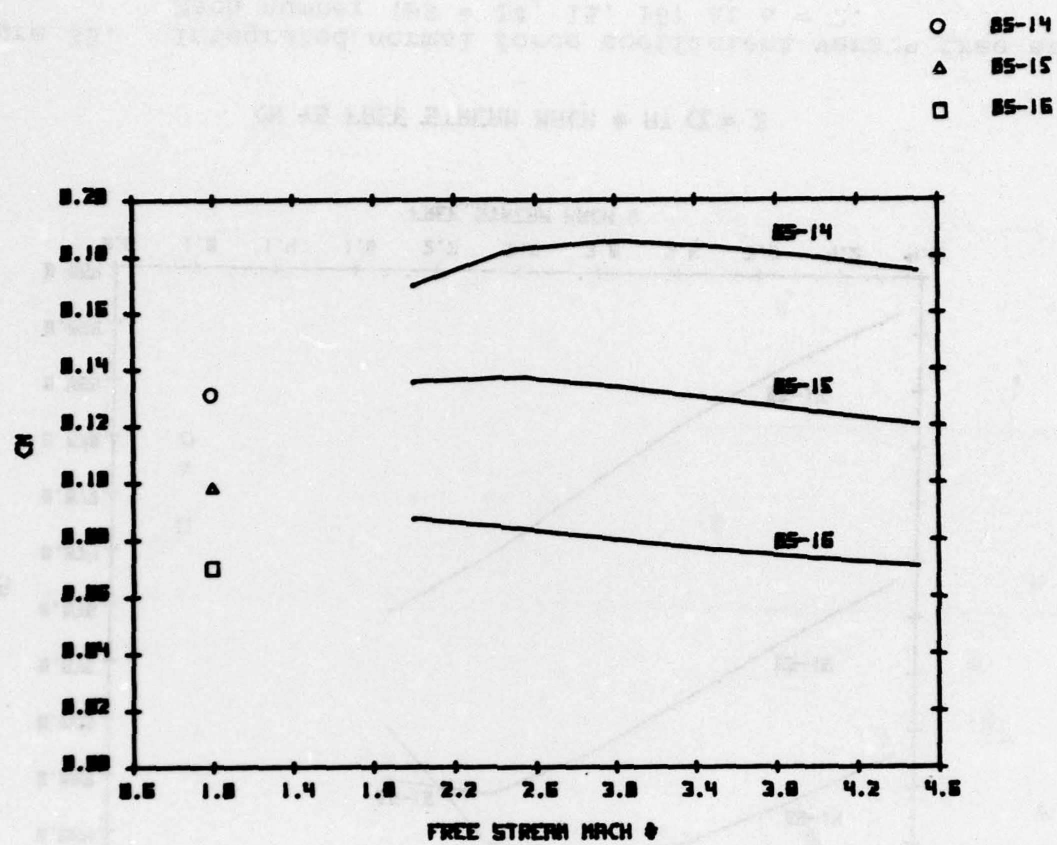


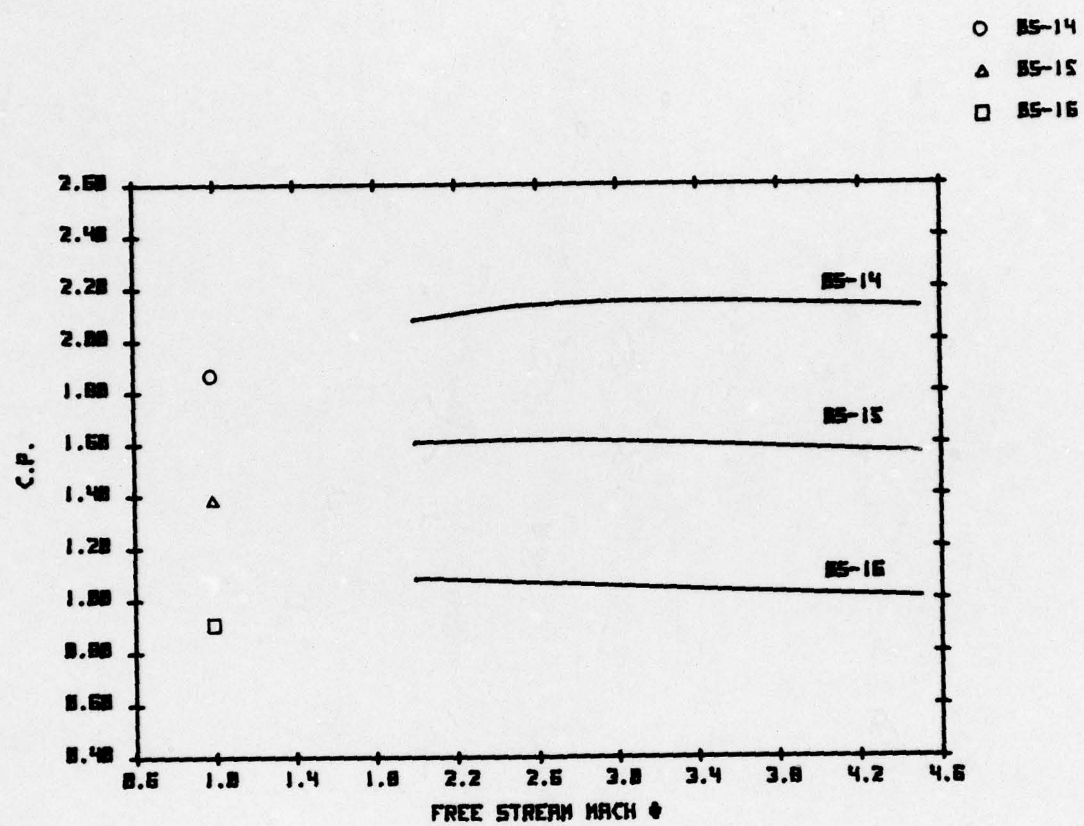
CN VS FREE STREAM MACH # AT α = 2

Figure 35. Integrated normal force coefficient versus free stream Mach number (BS = 14, 15, 16) at $\alpha = 2$.



CM VS FREE STREAM MACH # AT α = 2

Figure 36. Integrated pitching moment coefficient versus free stream Mach number (BS = 14, 15, 16) at α = 2.



C.P. VS FREE STREAM MACH # AT α = 2

Figure 37. Center of pressure versus free stream Mach number (BS = 14, 15, 16) at $\alpha = 2$.

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SYMBOLS

α	Alpha-Angle of attack
BS	Body shape (see Table I)
CM	Pitching moment coefficient about the nose
CN	Normal force coefficient
C.P.	Center of pressure - non dimensionalized with respect to D
D	Diameter of forebody at the base
L	Forebody length
L/D	Fineness ratio
M or M_∞	Free stream Mach number
X/D	Axial direction (non-dimensional)
R_N	Nose radius/D (non-dimensional)

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